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Consumer Valuation of Fuel Economy Over Time: 2003-2012

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CONSUMER VALUATION OF FUEL ECONOMY OVER TIME: 2003-2012

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ABSTRACT

This study is in-depth analysis of consumer valuation of fuel economy with the objective of assessing how that value has changed over time using ten years' of data covering 2003 to 2012 model year vehicle sales. Marginal willingness to pay for incremental change in fuel economy is estimated using hedonic price model for each model year. This value is then compared with the expected value of fuel savings of the increased fuel economy. The results of analysis show that valuations of fuel economy by consumers vary across vehicle classes and over time. The results of comparison indicate that marginal willingness to pay for incremental change in fuel economy (for all vehicles) generally but not perfectly tracks expected value of fuel savings and average fuel price over the years.

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CHAPTER ONE

INTRODUCTION

Automobile industry has been an important manufacturing sector in the world and one of the main reasons for oil dependence costs. For instance, cars and light trucks account for 63% of U.S. transportation petroleum use and 59% of U.S. transportation energy use in 2013 according to 32nd Transportation Energy Data Book. Following the 1973-oil crisis, changing economic conditions led to the introduction of new federal legislation to regulate fuel economy for vehicles in order to reduce the growing oil dependence costs. The U.S. Congress created the Corporate Average Fuel Economy in 1975 with enactment of the Energy Policy and Conservation Act, with the purpose of reducing oil dependency by improving average fuel economy for cars and light trucks sold in the market. This law established a minimum average fuel economy for each manufacturer's vehicle fleet of 18 miles per gallon (MPG) for cars and 17.2 MPG for light trucks beginning from 1978. The mandated sales-weighted average fuel economy for car fleet increased from 18 miles per gallon to 27.5 miles per gallon by 1985 and for light trucks from 16 mpg in 1980 to 22.5 in 2008. Thirty years after the introduction of CAFE, the Energy Independence and Security Act of 2005 established new requirements and much stricter standards for minimum average fuel economy. It increased minimum standards from 27.5 miles per gallon to 35 miles per gallon (40% increase), with the goal to be achieved by 2020. In 2009, the administration changed the compliance date to 2016 from 2020.

In 2011, the Obama Administration announced the new agreement to increase average fuel economy to 54.5 miles per gallon by 2025. This new CAFE regulation also introduces categorization of fuel economy based on the vehicle's footprint. A vehicle's footprint is determined by multiplying the vehicle's wheelbase by the vehicle's average track width. Then different fuel economy targets are set for vehicles based on their footprint, with lower MPG targets for vehicles with a larger footprint.

When fuel economy standards were first passed, it was assumed that technological advances would target fuel economy. However, Cheah and Heywood (2011) find that advances in vehicle technology have not resulted in reducing vehicle's fuel consumption but instead went to other vehicle attributes such as acceleration, horsepower and performance. McConnell also shows that there was initially a tradeoff between horsepower and fuel economy, with initial improvements in fuel economy correlated with reductions in horsepower between 1975 and 1981. However, between 1982 and 2006, horsepower nearly doubled while average fuel economy remained virtually unchanged. Also, automakers produced lighter vehicle in order to reach the minimum fuel economy standards. Since the aim of CAFE regulation is to reduce to oil dependency and to improve fuel economy, it is important to understand how consumers value fuel economy in order to assess this regulation's benefits and costs and whether or not this regulation is successful. While valuation of fuel economy has been studied many times in many ways in the past, this study aims to compare the consumer's

valuation of fuel economy for each model year from 2003 to 2012 and to understand how it changes over the time.

This paper will be organized into 5 sections. The next section reviews relevant literature in which other researchers have examine consumers' valuation of fuel economy. The next section describes the models estimated in this study, while I the data used in the estimations is explained in the section *after that.* The results are explained following that, and then summarized in the Conclusion, where limitations and possible extensions of this study are discussed.

CHAPTER TWO

LITERATURE REVIEW

Sherwin Rosen (1974) developed the methodology and the theoretical framework for hedonic prices as equilibrium prices in the context of competitive market in his prominent paper. Following his paper, his method has been used in many studies in different fields or areas, from real estate economics to Consumer Price Index. Court, an economist for General Motors, first used the hedonic price model in 1939 to compare the price of cars produced in different years, yet the attribute of fuel economy was not included in any hedonic regression until the 1970s.

Goodman (1983) followed the hedonic model developed by Rosen to estimate how fuel economy was valued with vehicle data on two-year-old cars in 1977 and 1979(1975 and 1977 model year vehicles). While fuel economy one model year was not statistically significant, the other year was significant.

Arguea, Hsiao, and Taylor (1994) estimated marginal value of fuel economy applying hedonic model to 1969-86 data compiled from Consumer Reports and Ward's Automotive Yearbook in two stages. In the first stage, they estimated the hedonic price equation and calculated the implicit prices of each characteristic of vehicles and later applied the derived implicit price to the model in order to estimate a demand-supply system of characteristics. This approach was new. They found that "a linear hedonic price function for attributes of vehicle is an adequate function."

Espey and Nair (2005) applied the hedonic price model to 130 vehicle models from the 2001 model year to estimate the marginal value of increased automobile fuel economy. For regression of vehicle price on vehicle attributes and fuel economy, they followed the methodology of Rosen. After calculating the value of 1-mile per gallon improvement in fuel economy and undiscounted value of fuel cost savings, they concluded “automobile buyers fully internalize fuel cost savings attributable to improved fuel economy at low discount rates”.

Fan and Rubin (2009) estimated the impact of demographic factors on consumer demands for fuel economy by using two-stage hedonic model. Their first-stage model estimates the implicit price of characteristics of vehicles. Their database contains complete vehicle attributes and demographic information on 523 passenger cars and 2,100 trucks in state of Maine in 2007. In first-stage model, the log of manufacturer’s suggested retail price was regressed on the logs of MPG, curb weight, horsepower to weight ratio, transmission, manufacturer, and vehicle class. In the second-stage model, all demographic variables were included in the model in order to measure consumer net benefits from a change in the quantity of an attribute across classes. Their result shows that a willingness to pay for a 1-MPG increase of fuel economy is $208 for car buyers and $233 for truck buyers. They found that consumers undervalue the long-run fuel savings of vehicle ownership and value short-run fuel savings.

Some studies (Espey and Nair, 2005; McManus, 2007;Matas and Raymond, 2009) find that consumers rationally value fuel economy when

purchasing vehicle, while Kurani and Turrentine (2007) concluded that consumers are myopic when deciding which cars are dependable.

In literature, some studies as explained above have estimated consumer willingness to pay for automotive attributes and a unit change of fuel economy through one single stage or two stage hedonic model while other studies (Berry, Levinsohn and Pakes 1995, Gramlich 2008, Allcott and Wonzy 2009) estimated the value of attributes of vehicles through alternative models such as discrete choice models and asset price models. Some studies also used survey-based methods as alternative way of consumers' evaluation of fuel economy. Turrentine and Kurani study is one of these non-hedonic studies. Turrentine and Kurani (2007) conducted a survey with a sample of 57 Californian households and found in their survey-based study that no household analyzed their fuel costs in a systematic way in their automobile or gasoline purchases. Almost none of these households track gasoline costs over time or consider them explicitly in household budgets. Moreover, they concluded that consumers value fuel economy more than fuel savings and as they stated in the paper that the value of fuel economy is more than differences in fuel costs, but includes other values such as non-quantifiable/ non-monetized values, and that those are unlikely to be processed in an economically rational algorithm under any conditions." Kurani and Turrentine study shows that consumers almost do not behave according to the rational economic behavior. Based on the survey data, "consumers do not think about fuel economy in the same way as experts, nor in the way experts

assume consumers do" and do not calculate fuel cost of vehicle while purchasing.

Gasoline price is a critical factor that affects peoples' decision of purchasing new vehicle. Gasoline price and new vehicle price relationship has been considered in many studies. Klier and Linn (2010) estimate the effect of gasoline prices on new vehicle demand by using a unique data set of monthly new vehicle sales by detail from 1970 to 2007. They found that the price of gasoline has a significant effect on the demand for fuel-efficient vehicles. Consumers shifted their preferences toward more fuel efficiency vehicles after the increase in the price of gasoline from 2002 to 2007. It implies that gasoline prices and regulations such as CAFE may affect the characteristics of vehicles in the market, including fuel efficiency. Similarly, McManus (2007) found that increase in gasoline price lowers the price of both cars and light trucks and the decrease in the price is much higher in light trucks compared to cars. Moreover, the negative impact of gasoline price on less fuel-efficient vehicle is much more than on more fuel-efficient vehicle. Timmins, Li and Haefen (2009) found that high gasoline prices affect fleet fuel economy by shifting new auto purchases towards more fuel-efficient vehicles. Allcott and Wozny (2009) tested whether the effect of $1 change in vehicle price is same as the effect of $1 change in discounted present value of fuel costs and found that "vehicle market equilibria under-adjust to changes in expected future gas costs: prices and market shares

move as if consumers are willing to pay only $0.61 up front to reduce discounted gasoline costs by $1."

The aim of this study, valuation of Fuel economy over time, has not been studied and considered properly in the literature. Espey (2013) estimated the value of fuel economy over the years 2001-2010 and compared it over time and found that "consumers do not value fuel economy at all in new vehicle purchase decisions, at least in 2005".

CHAPTER THREE

MODEL

Purchasing a vehicle is an investment paid now and its ownership lasts over its lifetime. The ownership of a vehicle requires a continuing the need for fuel over the course of vehicle lifetime. For this reason, fuel economy is taken into consideration while purchasing a vehicle to make a rational decision. The hedonic price model is used to value the attributes of a vehicle. “Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specified amounts of characteristics associated with them” (Rosen 1974).

According to the Rosen methodology, the coefficient of the hedonic equation results from the interaction of consumers and producers; in other words, it is the result of interaction of consumer’s marginal valuation and the producer’s marginal cost. The model has been used in a variety of applications such as housing, automobiles, computers, as well as air and water pollutions.

In this paper, hedonic price function is used to analyze the marginal value of increased fuel economy. Since the price of any good is a function of the prices of the bundle of its characteristics in a competitive equilibrium and automobiles embody a bundle of characteristics, the following function can represent the price of an automobile

$$P_{auto}=P\ (C_1, C_2, C_3,\ldots\ldots\ldots\ldots\ldots ,C_n) \qquad (1)$$

where C_i expresses a characteristic of vehicle. Each implicit marginal price of any one characteristic or attribute $p(C_k)$ is the partial derivative of the equilibrium hedonic price function with respect to that attribute C_k

$$p\ (C_k) = \partial P_{auto} / \partial C_k \qquad (2)$$

This value reflects the marginal willingness of consumers to pay for an additional unit of that characteristic and the firm's marginal cost of providing another unit of the characteristic thus Rosen's methodology, the marginal value of fuel economy can be estimated as the partial derivative of the hedonic price function of a vehicle with respect to fuel economy.

The specifications of the regression equations estimated in this study are all of the form:

$$\text{Y (Vehicle Retail Price)}_i = \beta_0 + \beta_1 (\text{Vehicle Size})_i + \beta_2(\text{Power})_i + \beta_3(\text{Performance})_i + \beta_4(\text{Safety})_i + \beta_5(\text{Reliability Rating})_i + \beta_6(\text{Comfort Rating})_i + \beta_7(\text{Vehicle Drive System})_i + \beta_8(\text{Vehicle Category})_i + \beta_9(\text{Fuel Economy})_i + \mu_i \qquad (3)$$

where "i" denotes each different vehicle model. In addition to fuel economy variable, this equation considers 8 independent variables of automotive attributes: Vehicle size, power, performance, comfort ratings, reliability ratings,

safety, vehicle category (light trucks and passenger cars) and vehicle drive system (AWD/FWD/RWD/4WD).

In this study, two models will be estimated using the regression equation described above, with fuel economy represented by both city and highway fuel economy, and average fuel economy. In each model, the inverse of fuel economy, thus gallons per mile, is used. Automobile price would be reversely related to fuel economy because fuel economy is expected to be valued for the fuel savings it provides. Moreover, Larrick and Soll (2008) found that using "miles per gallon" as a measure of fuel efficiency rather than "gallons per mile" leads people to undervalue the benefits of replacing the most inefficient automobiles.

3.1 Expected Value of Fuel Savings

According to Rosen's methodology, each vehicle's marginal price of each attribute equal's its buyer's marginal willingness to pay for it. For this reason, to evaluate how well consumers value incremental changes in fuel economy, the calculation of expected fuel savings from 1-mile increase per gallon is needed. Expected fuel savings depends on vehicle miles traveled (VMT) over the lifetime of vehicle, fuel economy of vehicle, and gasoline price such that:

- Fuel Cost ($) = Gasoline Price ($/g)* VMT/Fuel Economy (mpg) (4)

The fuel cost is estimated as the average retail gasoline price per gallon for each year multiplied by vehicle miles traveled in that year divided by average weighted miles per gallon. (See Appendix Figure 3.1 and Figure 3.2 for retail gasoline price and average vehicle miles traveled).

Expected fuel savings are calculated by taking the difference after 1-mile increase per gallon over the lifetime of vehicle.

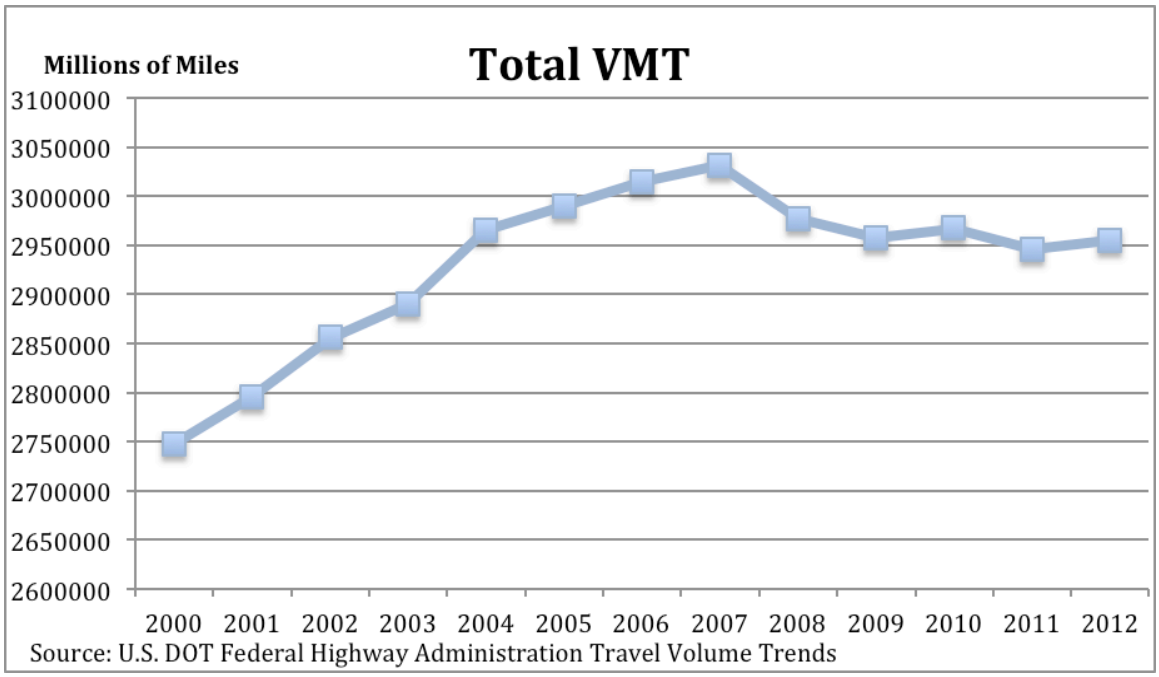
$$Expected\ Fuel\ Savings = \sum_{i=0}^{n} G \times M \times \left(\frac{1}{MPG} - \frac{1}{MPG+1}\right) \quad (5)$$

G indicates gasoline price and M denotes annual mileage in the year i.

Different assumptions about the lifetime of vehicle and VMT were used in past empirical studies. While some previous studies assumed that all vehicles travel 10000 miles in a year (Kilian 2006, Salee and West, 2008), Fan and Rubin 2009 assumed that estimated lifetime span is 17 years for passenger cars and 16 years for light trucks. In their study, they assumed that new vehicle ownership is 10 years, getting decreasing rate from NHTSA. Espey and Nair (2005) computed the undiscounted values of fuel savings by assuming 145000 miles as vehicle lifetime based on U.S. Department of Transportation report. Fifer and Bunn (2009) calculated expected fuel savings assuming 14 years a vehicle life span.

For this study, the value of expected fuel savings is based on 2009 National Household Travel Survey Estimates. According to the 2009 NHTS estimates, expected annual miles traveled decreases with a vehicle's age. Moreover, per capita VMT and total VMT have been decreasing since 2007 according to the Federal Highway Administration Traffic Monitoring Trend Reports.

Figure 3.3 Total Vehicle Miles Traveled in US



2009 National Household Travel Survey data on vehicle use by age of vehicles is used with annual mileage to interpolate average miles traveled per year for each model year vehicle. Only 2001 and 2009 estimates in NHTS data are used since my data set covers only model year of 2003-2012. I assume the total lifetime mileage of around 160,000 miles and calculated a use profile over time for each year. Then I make the calculation of expected fuel savings using 3%, 5% and 7% discount rates in order to compare each of those values with the marginal value of incremental change in fuel economy obtained from hedonic model function. (See Appendix Table 3.1 for the use profile for each model year and Figure 3.4 for the estimated use profile for each model year.)

CHAPTER FOUR

DATA

In order to assess the value consumers place on fuel economy in their vehicle purchase, data covering a 10-year period of vehicle sales in the United States from 2003 to 2012, consisting of 1280 different model-year combinations is analyzed. In addition to fuel economy (measured in gallons per 100 miles), the data includes: sales quantities, manufacturer's suggested retail price (MSRP), curb weight (as a measure of vehicle size), zero to 60 miles per hour acceleration time (as a measure of vehicle power), 180 degree turning circle distance (as a measure of performance), sixty to zero miles an hour brake distance and a crash test rating (both measures of safety), comfort rating, reliability rating, and vehicle drive system.

The MSRP, sales amount, and physical characteristics of the vehicle models were obtained from Ward's Automotive Yearbook. The data for acceleration time, turning circle, braking distance, crash test rating, comfort rating, and reliability rating were obtained from Consumers Reports. Albeit the average of model numbers is 128 per year, the number of vehicles for each year analyzed by the regression model varied depending on the availability of data on vehicles for that year. While some models were newly launched in the car market, others were discontinued. For example, since Oldsmobile was phased out in 2004, the data set includes only 2003 and 2004 model of this make. Another example is newly introduced Fiat 500. After launching through Chrysler

dealers in late 2011, the data set only contains the Fiat 500 for 2012. Manufacturer's suggested retail price (MSRP) is chosen as a vehicle price since real transaction price is not available as a data set. Since Wards Data and Consumer Reports data were merged, the lowest MSRP of model was chosen for a sub-model whose price is not available. Sales data also was based on each model or sub-model.

The data set consists of two parts: One part for passenger cars and one for light-duty trucks. For passenger cars, vehicles are categorized in six classes in the data set. Light-duty trucks are classified in four categories, Sport utility vehicles (SUV), Crossover utility vehicles (CUV), trucks, and vans. I excluded trucks and vans categories from my analysis because these two categories are often used for business purposes. The only light duty vehicles that are in the regressions are SUVs, CUVs and Minivans. In order to distinguish between passenger vehicles (cars) and vehicles in the "light truck" classification, a dummy variable, taking on a value of one for SUVs and CUVs and zero for passenger vehicles, is used.

Most of studies, which examine the valuation of fuel economy using hedonic model selected "Curb weight" as the best indicator for vehicle size since length, width and wheelbase do not reflect accurate vehicle size. Among all these size variables, curb weight (measured in pounds) has the highest correlation with other indicators as it is also observed in this data set (See Appendix Figure 4.1 and 4.2 for Curb Weight-Horsepower and Curb-Weighted-

Acceleration Correlation). Vehicle footprint, a more common current measure of vehicle size, was considered but the data was not available for this measurement for the earlier years of the data.

For the “power” category, acceleration time is selected as explanatory variable in order to evaluate the marginal value of power. Acceleration time calculates in how many seconds a vehicle goes from 0 to 60 miles an hour (mph) thus is a relative measure of power. Acceleration was chosen over horsepower, an alternative measure of power, because it is less strongly correlated with curb weight, the included measure of vehicle size.

As a safety feature, two variables are selected for the model: “Crash Test Rating” and “Braking Distance”. Crash test rating and braking distance data were obtained from Consumer Reports, as reported by the National Highway Traffic Safety Administration (NHTSA) and Insurance Institute for Highway Safety (IIHS), which test many aspects of many vehicles every year. Crash test is rated on a scale of one to five for both front and side crash tests. According to the NHTSA method of scoring, five is the best while one is the worst. Braking is the distance in feet that it takes for a vehicle to fully stop from the point at speed of 60 mph on dry pavement.

Comfort and reliability ratings are rated on a scale of one to five by Consumer Reports, with one being the lowest rating and five being best. Comfort, a high priority for most consumers, is measured in terms of ride comfort and cabin quietness for front-seat comfort. Reliability shows whether or not there

is any problem with vital vehicle components. Consumer Reports provides reliability information based on a comprehensive survey of six million magazine and subscribers. As Consumer Reports states in the magazine, the survey asks about any serious problems that automobile buyers have had with their vehicles in the preceding 12 months. The information is gained by survey provides reliable and comprehensive reliability ratings. (Consumer Reports 2006)

Performance is the other category considered in this research. Turning circle is used to measure the performance of vehicles. Turning circle, also known as turning radius, is the radius of circular 180 degree turn (U-turn) in feet that the vehicle is capable of making. Dummy variables are included in the model to control for the vehicle's drive system (4WD/RWD/FWD/AWD), whether it is four-wheel-drive, rear-wheel-drive, front-wheel-drive, or all-wheel-drive. Finally, a dummy variable is also added to the model to control for vehicles in the light truck category (SUVs and CUVs, considered together). Time dummy variable, which shows model year, were not used since the theme of this study is to compare each year of ten-year period in terms of marginal value of economy. Thus the assumption is that the demand for vehicles changes from year to year based on economic conditions that are not accounted for in the model, so a separate estimate is made for each model year.

Fuel economy data is obtained from Environmental Protection Agency, which tests vehicle and gets estimated figures, and Consumer Reports. While EPA provides separate city and highway fuel consumption per gallon, Consumer

Reports tests average fuel consumption, which is 150-mile mixed driving loop, in addition to city and highway fuel consumption. “City” represents urban driving and is calculated by driving in stop and go rush hour traffic. “Highway” denotes a mix of rural and interstate highway driving in a warm-up vehicle, typical of longer trips in free-flowing traffic (Consumer Reports, 2006). EPA figures in automobile manufacturer advertising brochures are estimates by their test. These figures are considered to have been over estimates of the fuel economy for years. EPA changed their testing system as of 2008 model year. However, Consumer Reports has continued to test in the same manner over time. It means that it is more reliable for comparing over time.

Curb weight, safety, horsepower, crash test rating and comfort and vehicle’s drive system are expected to have positive impact on while turning circle, acceleration and, braking, and fuel economy (gallons per mile) are expected to contribute negatively to vehicle price. Additionally, the sign of Light Trucks variable is expected to be negative since light duty trucks are object to fewer regulations compared to passenger cars. Other things equal, they would be less costly to automakers and likely to be sold for a lower price.

Weighted means of retail price variable, which is undiscounted, generally increases over the ten years. It decreases from 2005 to 2008 and starts to increase in 2008, continuing upward. For instance, the sales weighted mean of retail price in 2003 is $24165.65 but it is 28245.9 in 2012. I found that Light truck

vehicles are more expensive than passenger cars across the ten years in my data set (See Appendix Figure 4.3)

Weighted means of Curb weight is fairly constant even though it is decreasing and increasing over the years. It is about 3500 pounds. As expected the mean of light trucks is higher than passenger cars. The difference curb weight between light truck and passenger cars is approximately 1000 pounds. (See Appendix Figure 4.4)

Brake distance variable as safety indicator has been decreasing over the years as seen in Figure 4.5. Brake distance of Light truck is longer than passenger cars. Other safety features, front crash test rating and side crash test rating, are fairly constant over the years (See Appendix Figure 4.6). These two ratings are ranged in vicinity of 4.5.

Multicollinearity was tested for each regression model and it was found that there is no multicollinearity problem in the data regressions except 2005.

Summary statistics for each year are shown in Tables in Appendix. Average gasoline prices for each year, used in calculation of expected fuel savings from improvements in fuel economy, is obtained from Energy Information Agency and is shown in Figure 3.1 in Appendix and in Table 4.1 below. Average miles traveled per vehicle, also used in this calculation, is obtained from Federal Highway Administration and shown in Figure 3.4. Lastly, a sales-weighted market share of cars versus light trucks is shown in Figure 4.7.

Table 4.1 Annual Average Retail Price

YEAR	Average Fuel Price $/G	YEAR	Average Fuel Price $/G
2003	1.60	2008	3.31
2004	1.89	2009	2.40
2005	2.31	2010	2.83
2006	2.62	2011	3.58
2007	2.85	2012	3.69

CHAPTER FIVE

RESULTS

5.1 Hedonic Estimation Results

Three models are estimated for each year of 10-year period with fuel economy, which is inversely entered in the models for comparison. While the first model and second model estimates fuel economy for passenger cars and light duty vehicles, the third model estimates fuel economy for all vehicles in the data set and vehicle category (light duty vehicles, which here includes just SUVs and CUVs) is included as a dummy variable in the model.

Next, for each category (light duty, passenger, all-vehicle estimations), two models are estimated, one using average fuel economy and the other including both city and highway fuel economy together. Regression results are shown in Tables 1-6. All models are estimated using least squares weighted by actual sales.

For all-vehicle model with average fuel economy, Curb weight variable is positive, statistically significant and fairly consistent over the years as expected. (See Figure 5.1) the sign of Acceleration variable is negative and statistically significant. It is also fairly consistent from 2005 to 2012 (See Figure 5.2). However, I found that some other variables are statistically insignificant and the sign is not as expected in some year. For instance, even though crash test rating means more safety, which would be expected to increase retail price of a vehicle,

the sign of crash test rating is not consistently positive over the ten years (See Figure 5.3).

Comfort rating, which is expected to have a positive impact on MSRP, is only statistically significant in 2004 and 2011. Even though it is statistically significant in 2006, it is not economically significant since its sign is not positive. Reliability rating, which is also expected to be positive, is only statistically significant in 2004 and 2006. The sign of reliability variable is negative but not statistically significant in 2004, 2005, and 2011. (See appendix figure 5.4).

I found that turning circle is only statistically significant in 2007; however, the sign is not negative as expected. (See appendix figure 5.5). Average fuel economy variable is only statistically significant in 2003, 2004, 2007 and 2008 models. However, the sign of coefficient is positive in 2003.

I estimated similar results above for other regression model, which uses both city and highway fuel economy, for all-vehicle. Curb weight variable is statistically significant and fairly consistent over the years. Likewise, acceleration is also statistically significant and its sign is negative as expected. The result of other variables is statistically significant in only some year and the sign is not as expected every year in the model.

Fuel Economy variables in the model is statistically significant together in only 2008 model. Whilst city fuel economy variable is not statistically significant in other years, highway fuel economy is statistically significant in only 2007 and 2010.

I obtained similar results for the light trucks and passenger cars variables in their regression models. (See appendix for summary statistics and regression results). Average fuel economy in the model for light trucks is statistically and economically significant only in 2010 model.

As mentioned, the theme of this study is to find how consumers value fuel economy by estimating the hedonic price of vehicles sold in the United States over a ten year time period. For the calculation and comparison with discounted fuel savings I use average fuel economy, which is more representative compared to city and highway fuel economy. The means of average fuel economy is shown in Figure 5.7.

The figure shows that passenger cars are more fuel efficient than light trucks as expected. Whilst average fuel economy for all vehicles was 20.47 mpg in 2003, it increased by 3 miles per gallon by 2012. Generally average fuel economy for both light trucks and passenger cars have increased approximately 3 miles per gallon over the ten years. In addition to average fuel economy, I got similar results for city and highway fuel economy in passenger cars and light trucks. The increase in fuel economy over the years is about 3 miles per gallon for both vehicle categories. However, the highest improvement in highway fuel economy is for passenger cars with 7 miles per gallon. Consequently there is a slight increase in fuel economy improvement over the years (See Figure 5.8 and Figure 5.9)

5.2 Hedonic Price Estimation for Fuel Economy

As mentioned above, the model with average fuel economy for each category is used to assess the value consumers place on fuel economy. Stata program was used to test the assumptions of non-linear regression.

Consumer marginal willingness to pay for fuel economy is calculated by Equation 3. To estimate the savings from an improvement in fuel economy, I use the estimation of sales weighted fuel economy for each year and calculate the gallons per mile for a one mile per gallon higher level of fuel economy. Then the incremental value of the change is as follows

Hedonic Price= $(GPM_2 - GPM_1) * \beta_9$ (6)

(β_9 indicates the coefficient of fuel economy from the hedonic model.)

First regression model estimation with average fuel economy, which includes all vehicles in data set, indicates that a marginal willingness to pay for 1-mile increase in fuel economy for vehicles is -$519.2 in 2003. As stated above, the coefficient of fuel economy variable in 2003-year model is not economically significant due to its sign. Hence it was not included in the comparison. In 2004, marginal WTP of 1-mile increase is $223.1. The marginal willingness to pay for a 1-mile increase in fuel economy ranged from $161.03 to $653.08. WTP is generally in vicinity of $200 except in 2007 and 2008. Not surprisingly, it is highest in 2007 with 653.08. Midway through 2008, fuel prices dropped and sales volumes had already slowed.

Second regression model estimation, which tests passenger cars, with average fuel economy shows that a marginal willingness to pay 1-mile increase in fuel economy for passenger cars is $497.69 in 2003. It ranged from $17.5 to $927.12. Each sign for each year is as expected; however, fuel economy variable is only statistically significant from 2003 to 2008. The highest level is $927.12 in 2005.

Third and last regression model estimation of light trucks, with average fuel economy indicates that only fuel economy in 2010-year model is statistically significant with the highest WTP level of $700.8.

However, it is not logical for an increase in fuel economy to decrease vehicle price, all else constant. As seen in the Figure 5.10, the increase in fuel economy is more significant and much valued for passenger cars than for light duty vehicles. The trend for passenger cars is declining across the years. This result is consistent with the results of sales-weighted average fuel economy, which has declined by 3 miles per gallon. As miles per gallon increases, the marginal value of an additional one-mile per gallon increase declines, as it equates to lower fuel savings than for lower starting levels of fuel economy.

5.3 Comparisons and Rationality

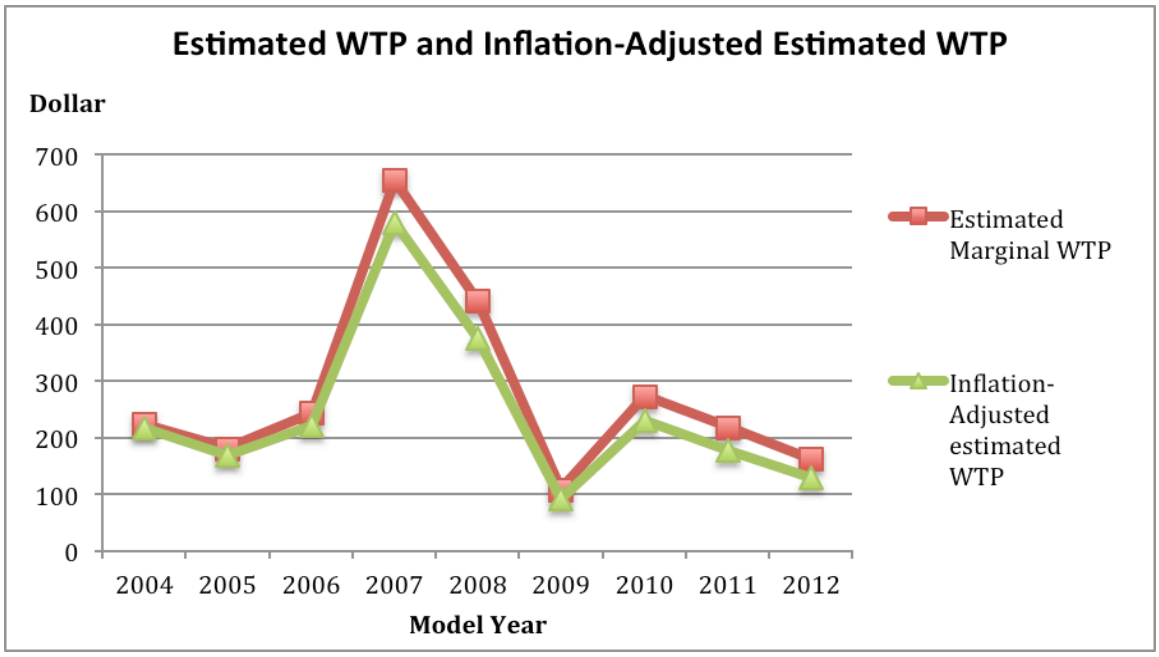
In order to compare these estimates to actual fuel savings, I need average vehicle miles traveled (VMT), fuel price, and sales weighted fuel economy in order to calculate fuel savings from 1-mile increase of fuel economy. The assumption based on vehicle life span and vehicle miles traveled during its

lifetime, which is described in the Model section, is used for average vehicle miles traveled. The expected value of fuel savings is calculated by the equations 4 and 5. Alternatively, a moving average of previous three years' gasoline price instead of the current price were also used in the calculation of fuel savings. If one were to use previous three years' gasoline price, the calculated fuel savings line would be much smoother.

According the assumption for each model year, each model year has different vehicle life span and vehicle miles traveled for each year. For example, the estimated life span of 2003 model year is 14 years while of 2007 model year is 16 years because average annual mileage driven decreased. However, lifetime use of a vehicle is approximately 162000 miles, which is consistent with previous findings of NHTSA (See the appendix for Table 3.1).

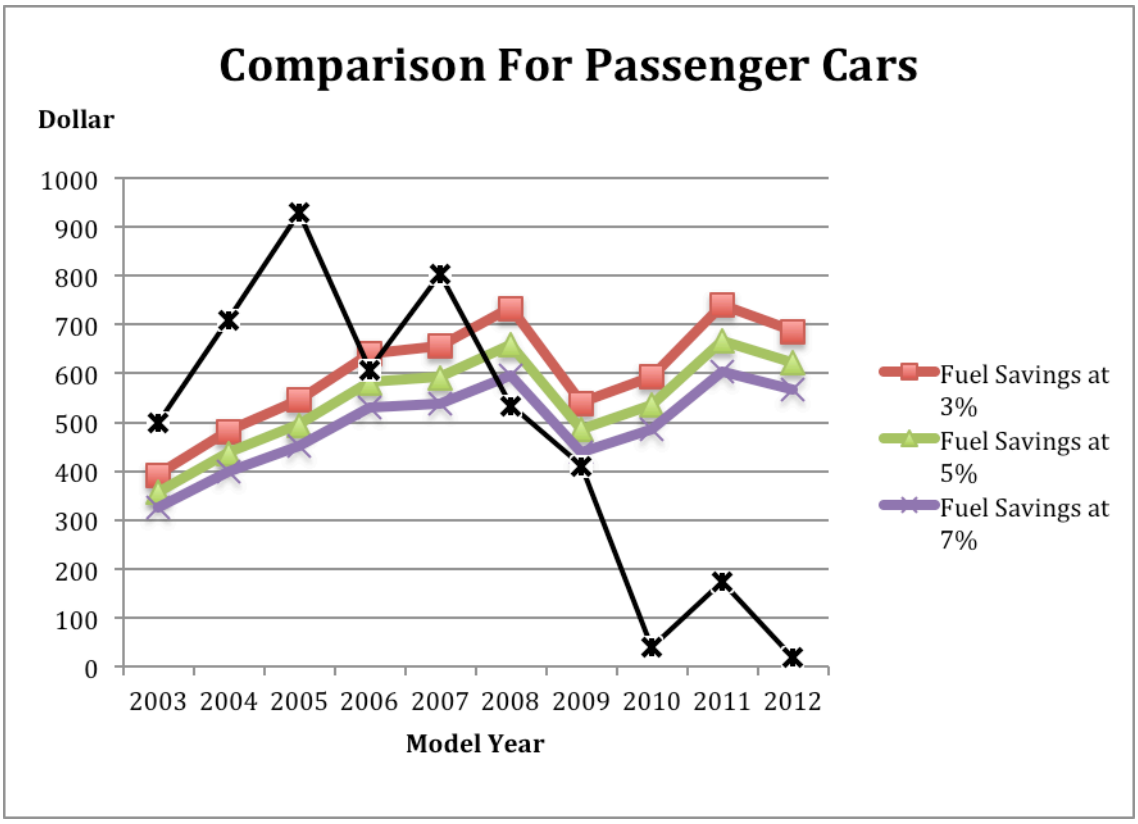
I calculated the estimated present value of fuel savings using 3%, 5%, and 7% discount rates for better comparison instead of using undiscounted fuel savings. The expected present value of fuel savings resulting from 1-mpg increase in the average fuel economy of passenger cars in 2004 is $480.57 at the discount rate of 3%, $436.1 at 5% and $398.5 at 7%. In the same year, it is $924.93 at 3%, $839.4 at 5% and $767.07 at %7.

Figure 5.11 Comparison of WTP to Inflation-Adjusted Estimated WTP



Adjusting both calculations for inflation is necessary to more accurately compare across years but I got similar trends for both calculations. To illustrate this point, I compared the estimated marginal willingness to pay (WTP) for all-vehicles to the inflation-adjusted estimated WTP (Figure 5.11). Since adjusted for inflation does not change the results it was not included in the study.

Figure 5.12 Comparison of Fuel Savings and WTP For Passenger Cars

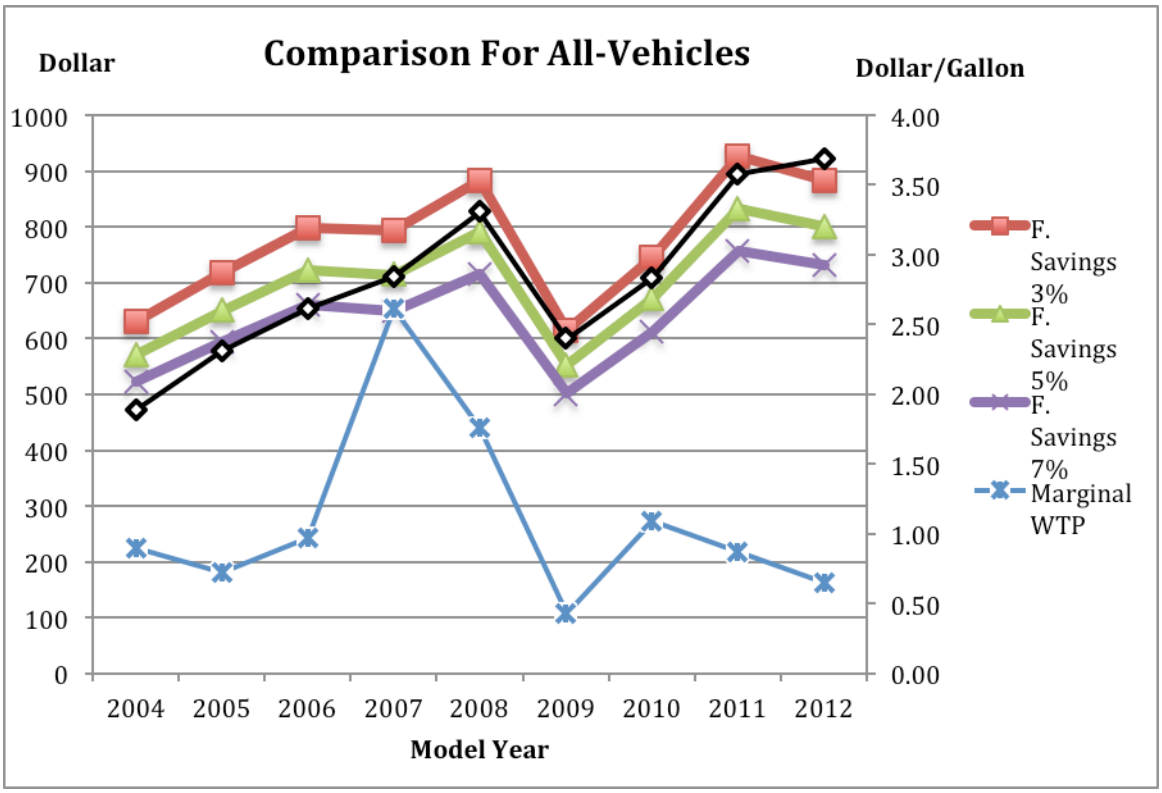


As stated before each average fuel economy variable for passenger cars from 2003 to 2007 is statistically significant. The graph shows how estimated present value of fuel savings and marginal willingness to pay for additional 1-mile in fuel economy for passenger cars vary over the time. Fuel savings is shown at three discount rates. I found that marginal willingness to pay for 1-mpg increase in average fuel economy is higher than the estimated present value of fuel savings in each model from 2003 to 2007. After 2007, estimated marginal willingness to pay has been declining dramatically.

I do not include the graph of comparison for light truck because of the number of statistically insignificant and positive coefficient results, which means negative estimated value of fuel savings. The model year of 2003, 2005, 2006, 2009 and 2010 has positive sign of fuel economy variable. Present value of fuel savings increases until 2008 and it is fairly stable in last four years. While WTP is $647.43 in 2004, it sharply declined in 2007 and is tracking stable trend until 2011. The coefficient estimates for average fuel economy and willingness to pay for additional increase for fuel economy is found very low for light trucks. I found that only average fuel economy variable in 2007 is statistically significant and the marginal willingness to pay for this year is $43.47.

The estimates for light trucks may be skewed in 2008 and 2009 by the fact that I use MRSP and many of these vehicles sold for way below MSRP as gasoline prices hit their peak (2008) and after the recession hit (2008-9). Automobile buyers therefore paid much less. It shows that automobile buyers may place less weight on fuel economy than they actually are since they paid a high price for less fuel-efficient vehicles.

Figure 5.13 Comparison of Fuel Savings and WTP For All Vehicles

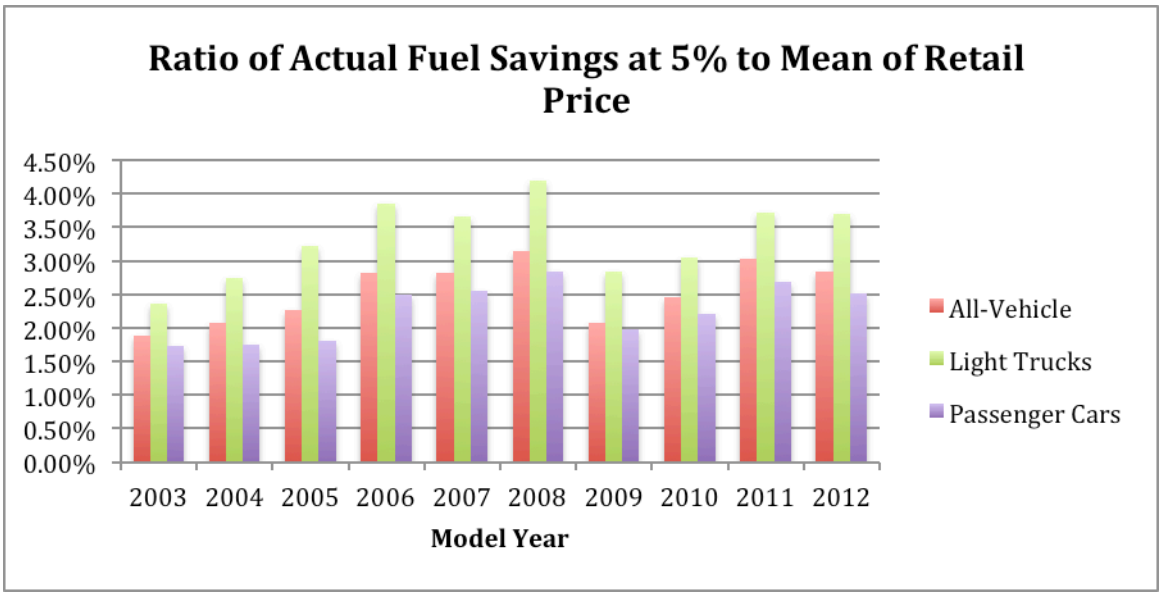


The last graph for comparison shows how estimated present value of fuel savings and marginal willingness to pay for additional 1-mile in fuel economy for all vehicles vary over the time. What is interesting is that the coefficient estimates of each regression model generally, but not perfectly, track the actual expected present value of fuel savings over time. According to the graph, the comparison of expected presented value of fuel savings to marginal willingness to pay for 1-MPG increase in average fuel economy shows that consumers perhaps undervalue fuel economy except in 2007. Alternatively, they may have a

higher discount rate, expect lower annual mileage driven, or expect a lower fuel price in the future.

I added annual average retail fuel price as a right-hand scale in the Figure 5.12 in order to observe how it changes along with both expected present value of fuel savings and marginal willingness to pay for 1-mile increase over the time. It perfectly tracks the actual expected present value of fuel savings over time. Declining fuel price in 2008 and 2009 addresses the decline in the estimates in 2008 and 2009.

Figure 5.14 Ratio of Actual Fuel Savings at 5% to Sales-Weighted Mean of Retail Price



The ratio of actual fuel savings at 5% to the sales-weighted mean of retail price for each model year is shown in the graph above. I did not only use the model year, which the fuel economy coefficient estimate is statistically significant and

the sign is negative as expected, to see how the ratio changed over the time. For those years, the ratio for all vehicles is respectively 2.08%, 2.81% and 3.15% in 2004, 2007 and 2008. For passenger cars, the ratio ranged from 1.73% to 2.84% while the ratio for light trucks in 2010 is 3.05%. The graph shows that actual fuel savings are pretty small relative to the price of a vehicle. Hence, it is not surprising that some estimates of fuel economy are statistically insignificant.

CHAPTER SIX

CONCLUSION

This study is in-depth analysis of consumer valuation of fuel economy with the objective of assessing how that value has changed over time using ten years' of data covering 2003 to 2012 model year vehicle sales. The results of analysis show that valuations of fuel economy by consumers vary across vehicle classes and over time. The results of fuel economy for passenger cars are generally found statistically significant while only one model year's fuel economy variable for the light trucks is found statistically significant. To get better comparison, both passenger cars and light trucks are also considered together as third model. This model shows that fuel economy variable for all vehicles is found statistically and economically significant for model years of 2004, 2007 and 2008.

Marginal willingness to pay for incremental change in fuel economy for the average vehicle ranged from $107.8 in 2009 to $653.1 in 2007. However, for a marginal increase of fuel economy, light truck buyers are willing to pay from $5.63 to $700.8 while passenger cars buyers are willing to pay in the range of $17.5-$927.12. For all vehicles, WTP generally stayed in the range of $100-$300 but peaked in 2008.

This study found that automobile buyers appear to undervalue fuel economy relative to the expected fuel savings it is likely to generate. It was also found that car buyers possibly overvalue fuel economy at a 7% discount rate in 2007. It is not entirely surprising that fuel economy appears to have a relatively

low market value. Expected fuel savings discounted at 5% is quite small relative to the mean retail vehicle price over these years, less than 2 percent prior to 2006, for example, and only slightly over 3 percent in 2008. Nonetheless, this study finds that automobile buyers do value fuel economy. The results indicate that marginal willingness to pay for incremental change in fuel economy generally but not perfectly tracks expected value of fuel savings and average fuel price over the years. Between 2004 and 2007 for example, fuel price increased by about 50 percent. It decreased by about 70 percent after 2008. In this period, consumers responded to this increase in fuel price by placing more value on fuel economy and to the dramatic decrease in fuel price by placing less value on fuel economy.

A significant part of this adjustment in fuel economy comes through the mix of vehicles purchased. The market shares of light truck decreased up to 2009 and it again started to increase after 2009. Also the sales weighted fuel economy for both light trucks and passenger cars increased by 3 mpg over the time. Thus consumers shift away from light trucks toward passenger cars and toward more fuel-efficient vehicles within the light truck or passenger car category as fuel prices rise.

My research has limitations as every study has. Firstly, the sample size mainly limited the study to get better results. The reason of having small size is due to lack of available consumer reports data. More consumer reports data would provide better understanding of consumers' valuation. Not using actual

sales price is another limitation. Actual sales price would reflect better understanding of how consumers value fuel economy. The last limitation is that only one sub-model for some models represents all sales of a given model. Future research will consider more years in order to understand the effect of more recent CAFE legislations and investigate how valuation of fuel economy in alternative fuel vehicles changed over the time.

APPENDICES

Appendix A

FIGURES

Figure 3.1 Monthly Retail Gasoline Prices

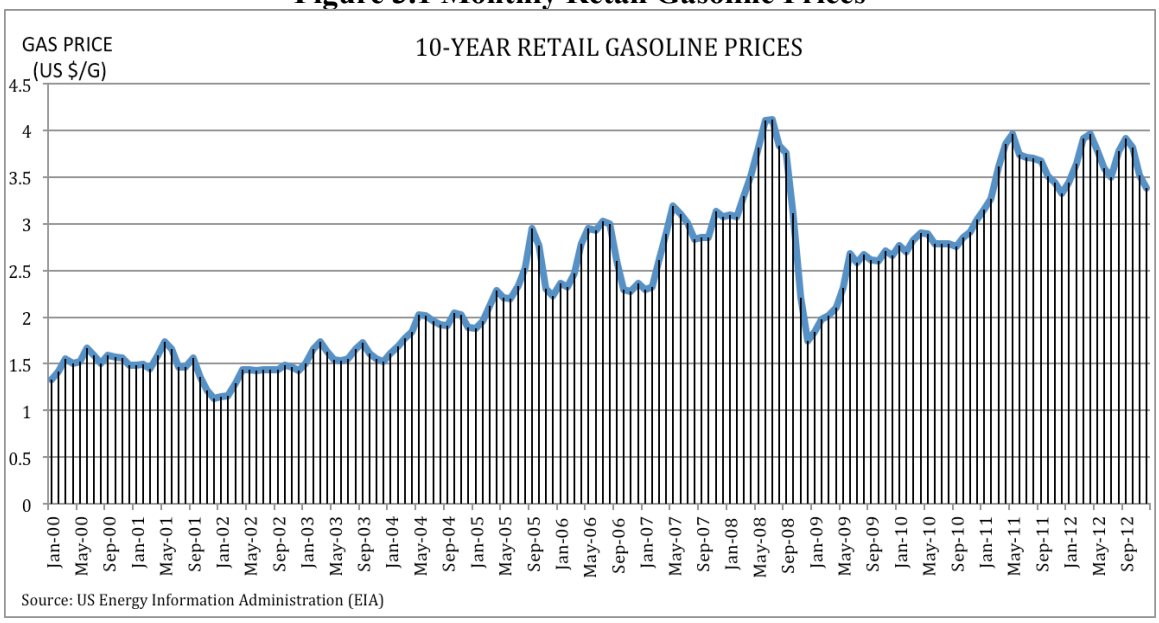


Figure 3.2 Average Vehicle Miles Traveled for Each Model Year

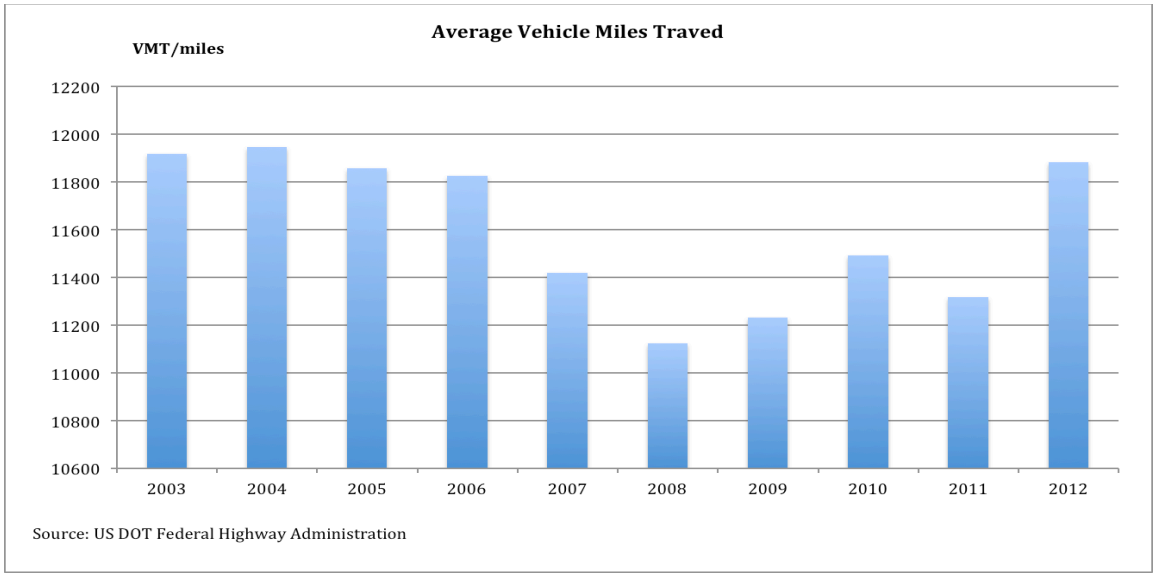


Figure 3.4 Estimated Vehicle Use Profile

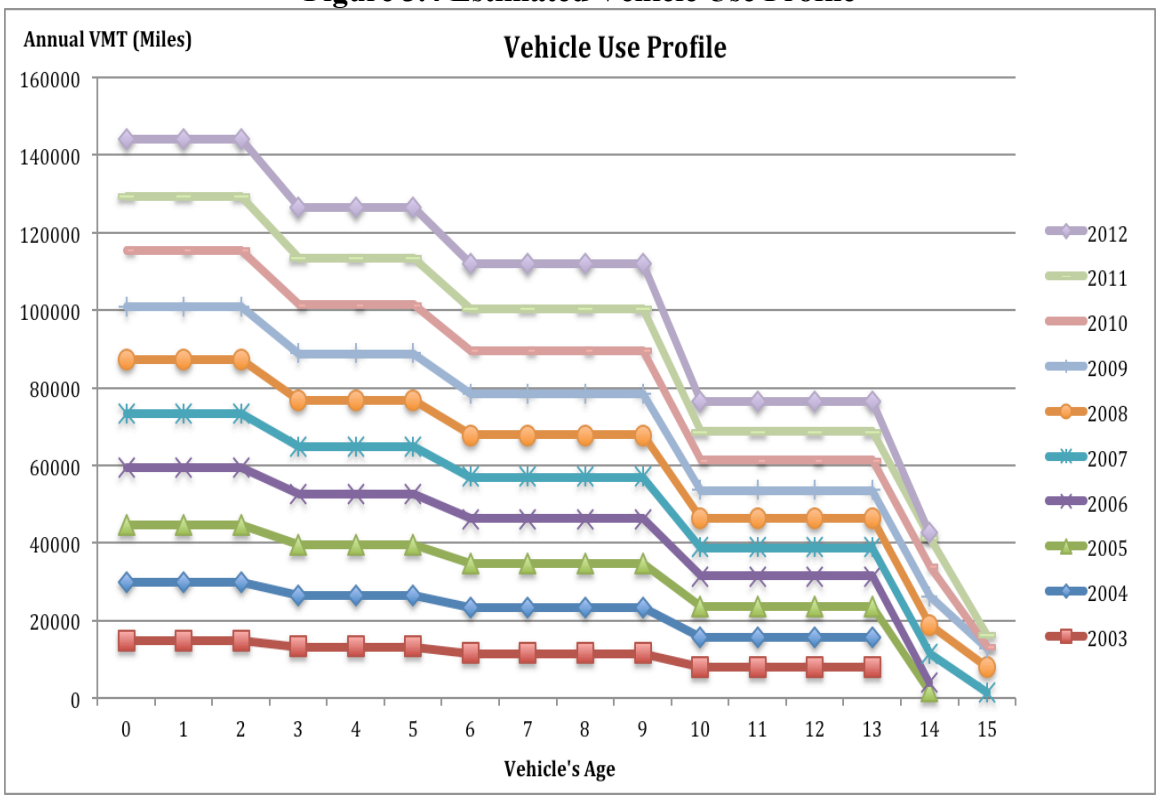


Figure 4.1 The Correlation between Curb Weight and Horsepower over the 10-years

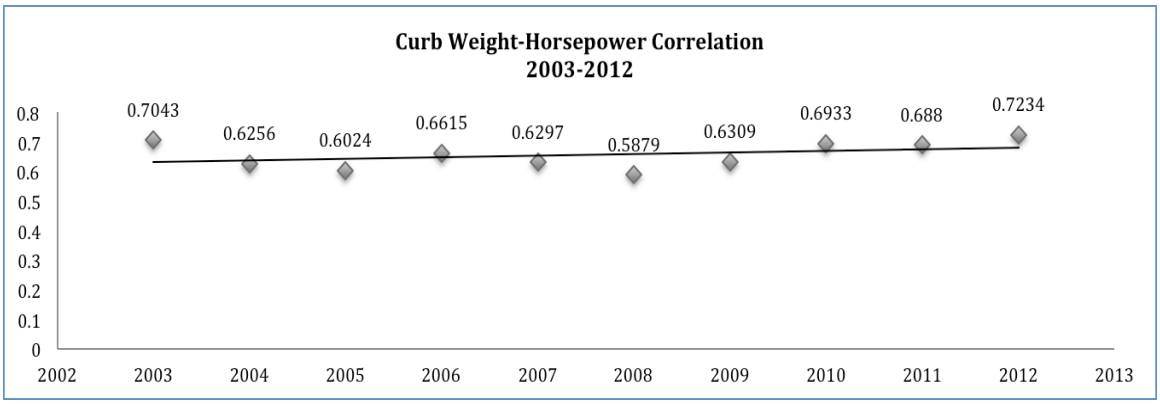


Figure 4.2 The Correlation between Curb Weight and Acceleration over the 10-years

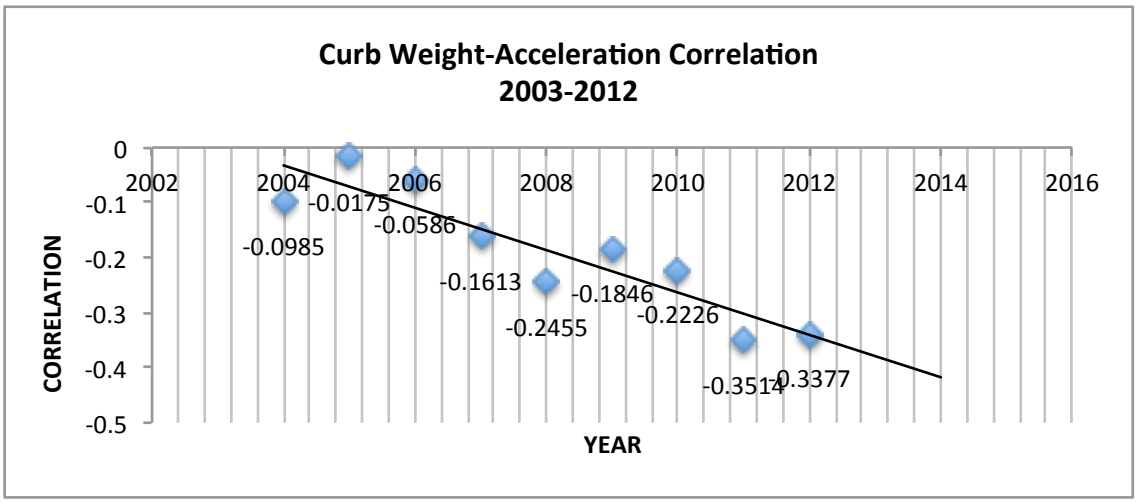


Figure 4.3. Sales-Weighted Means of Manufacturer Sales Retail Price

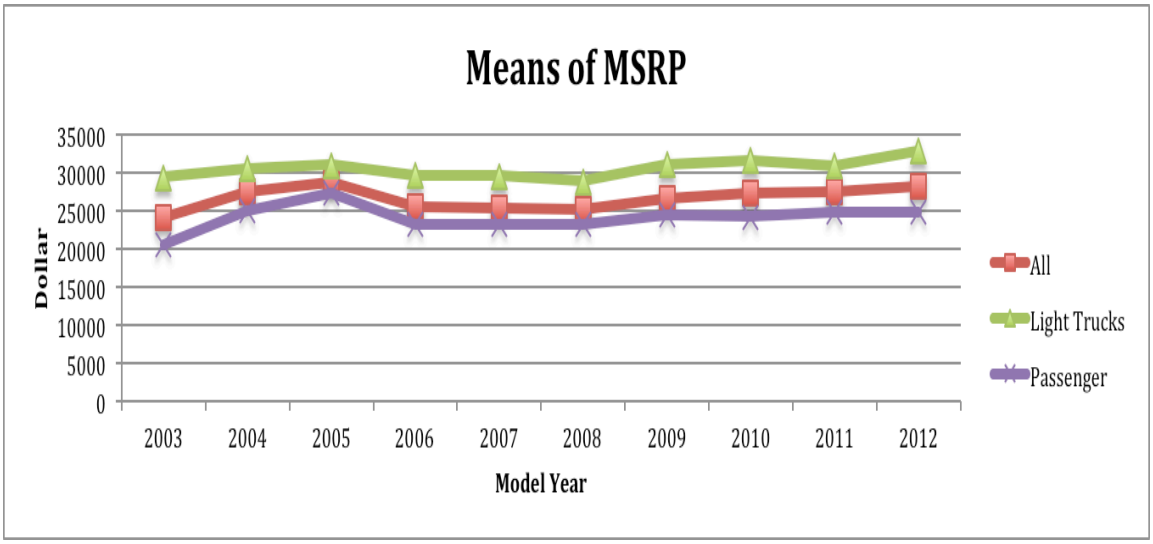


Figure 4.4. Sales-Weighted Means of Curb Weight

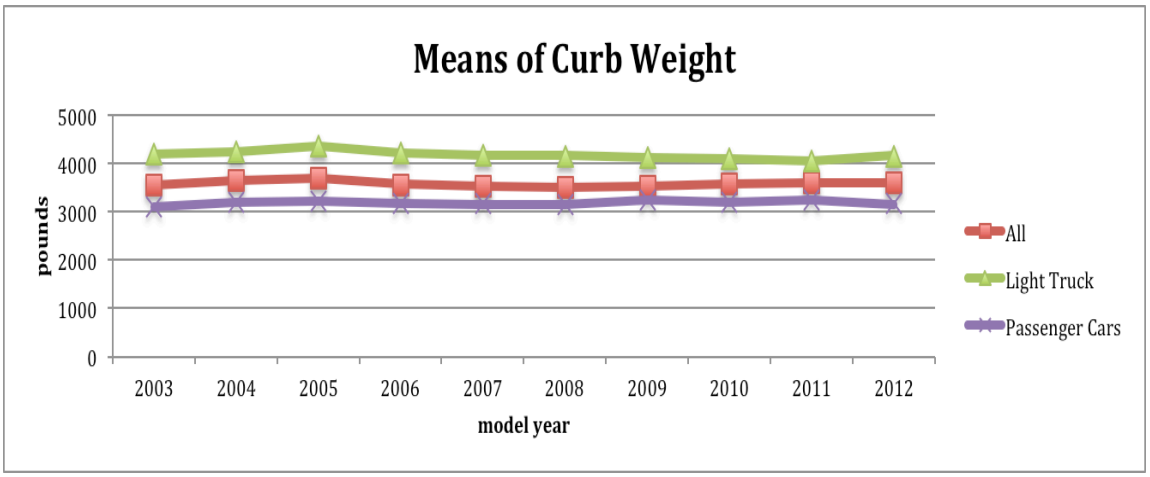


Figure 4.5. Sales Weighted Means of Brake Distance

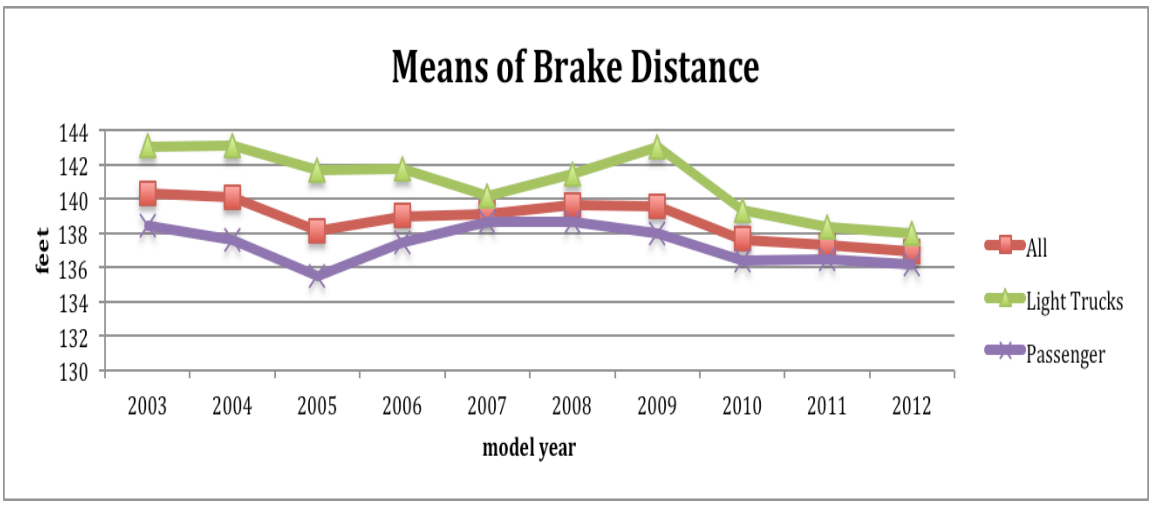


Figure 4.6. Sales-Weighted Means of Front and Side Crash Test Rating

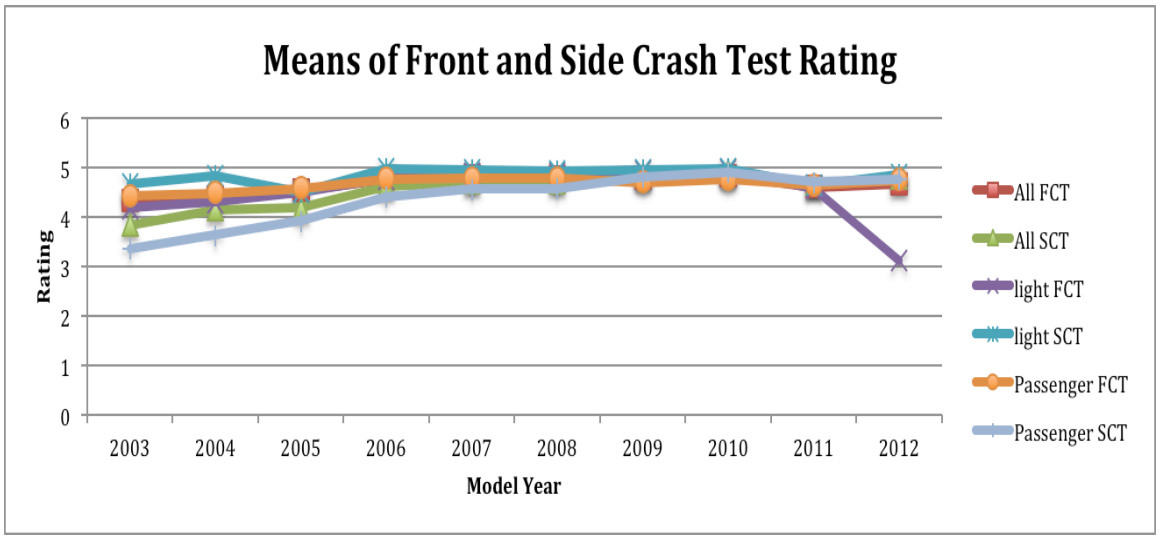


Figure 4.7 Market Shares of Cars vs. Light Trucks

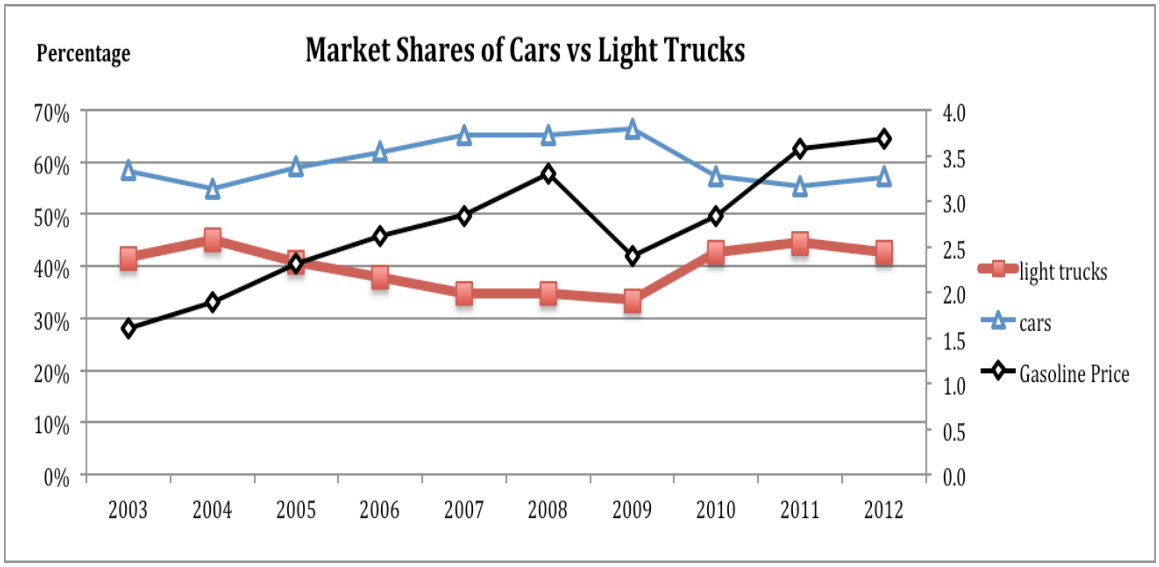


Figure 5.1 Coefficient Estimates of Curb Weight

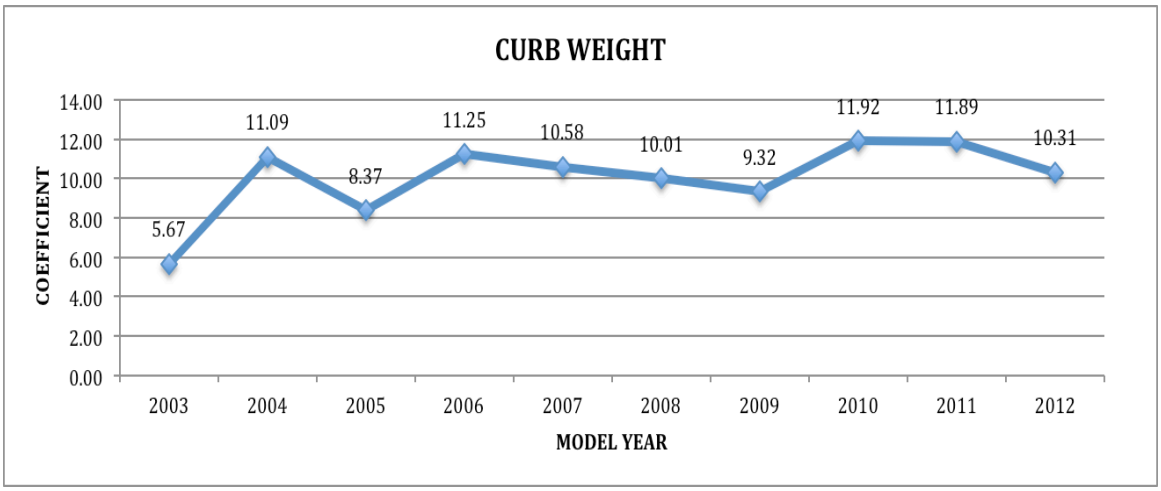


Figure 5.2 Coefficient Estimates of Acceleration

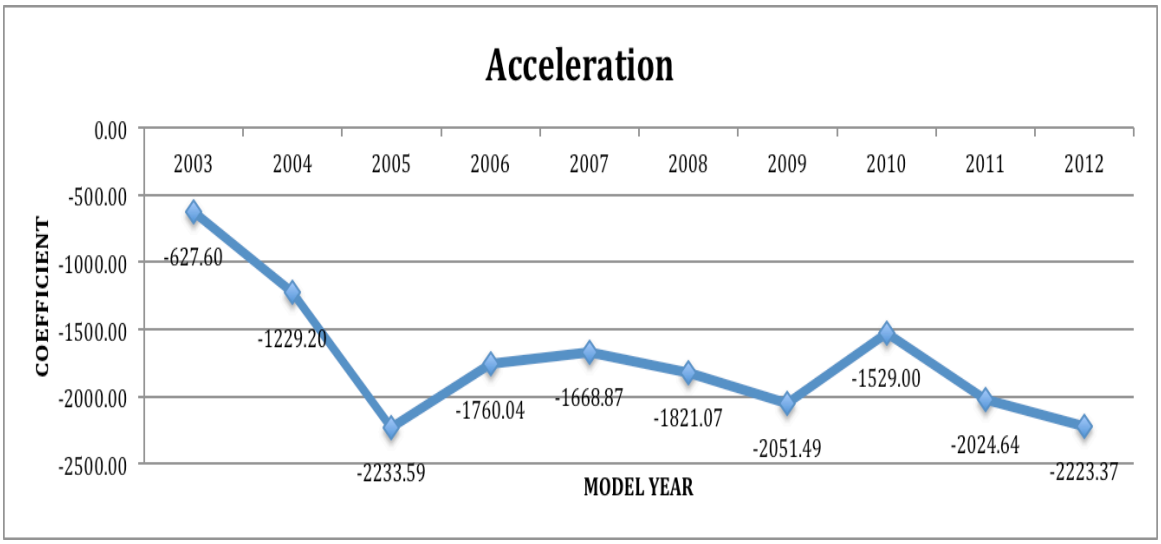


Figure 5.3 Coefficient Estimates of Front and Side Test Ratings

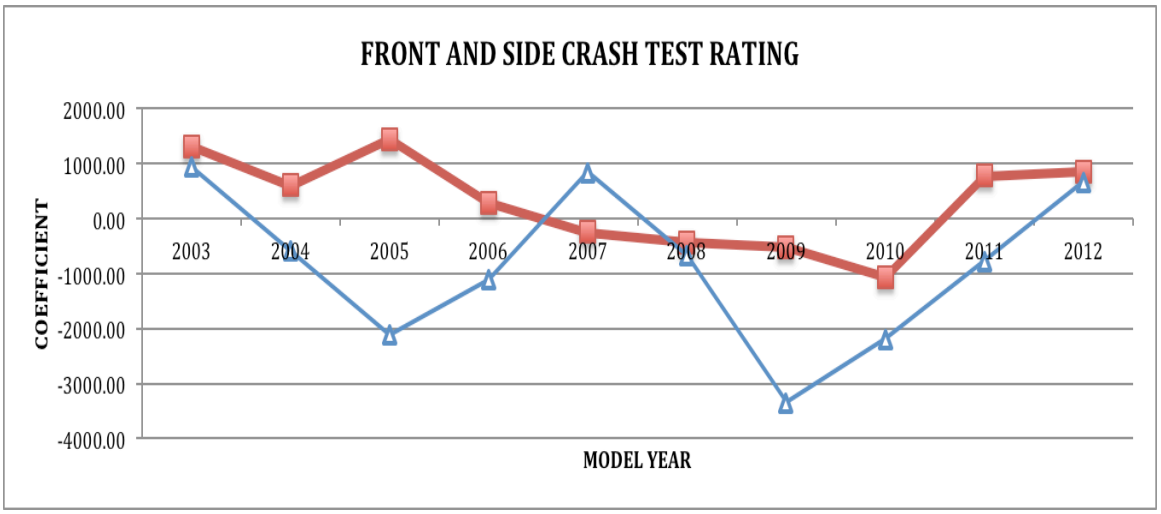


Figure 5.4 Coefficient Estimates of Comfort and Reliability Ratings

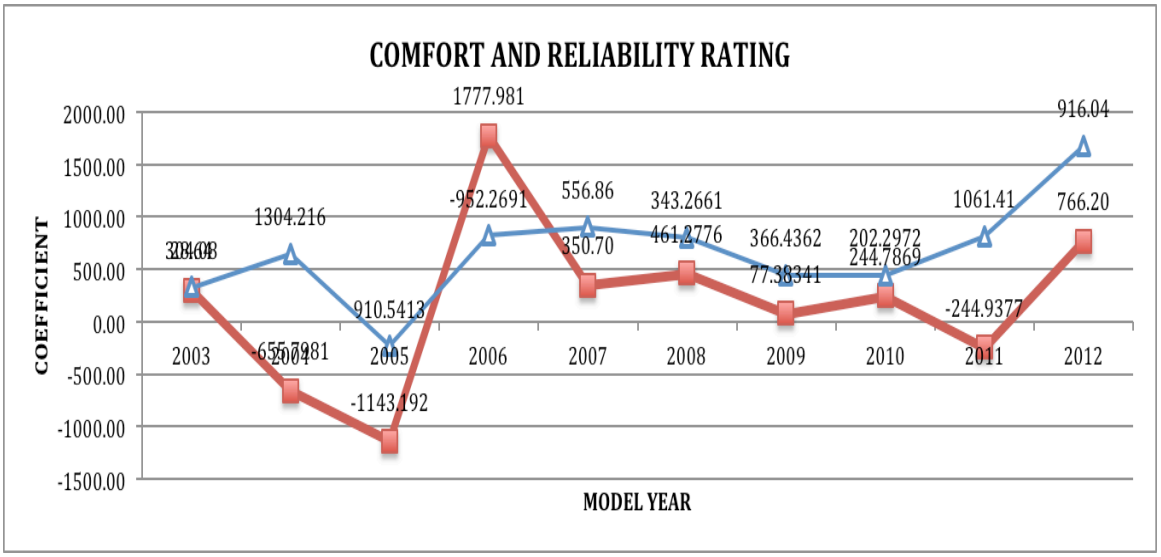


Figure 5.5 Coefficient Estimates of Turning Circle

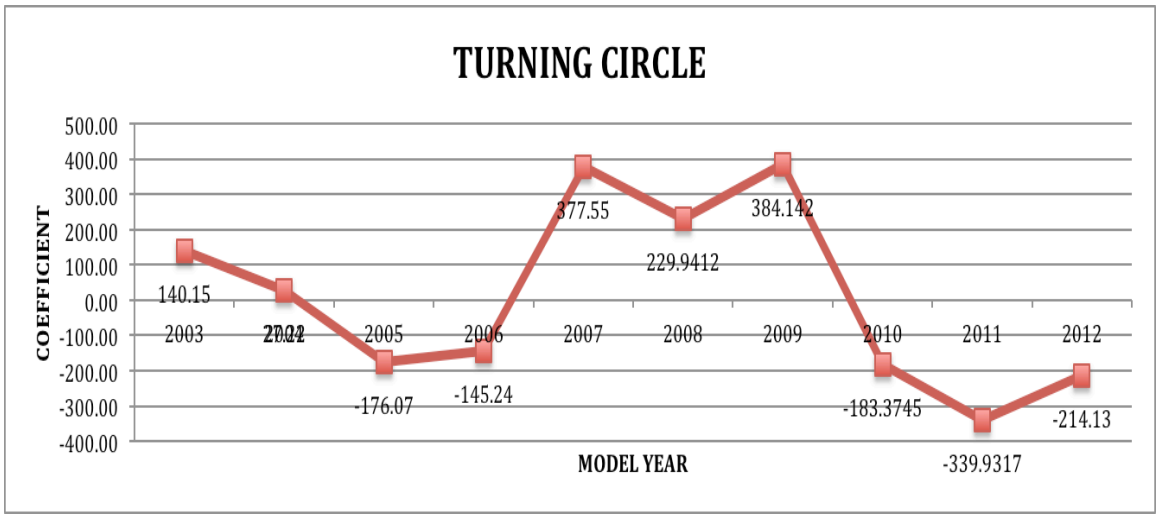


Figure 5.6 Coefficient Estimates of Brake Distance

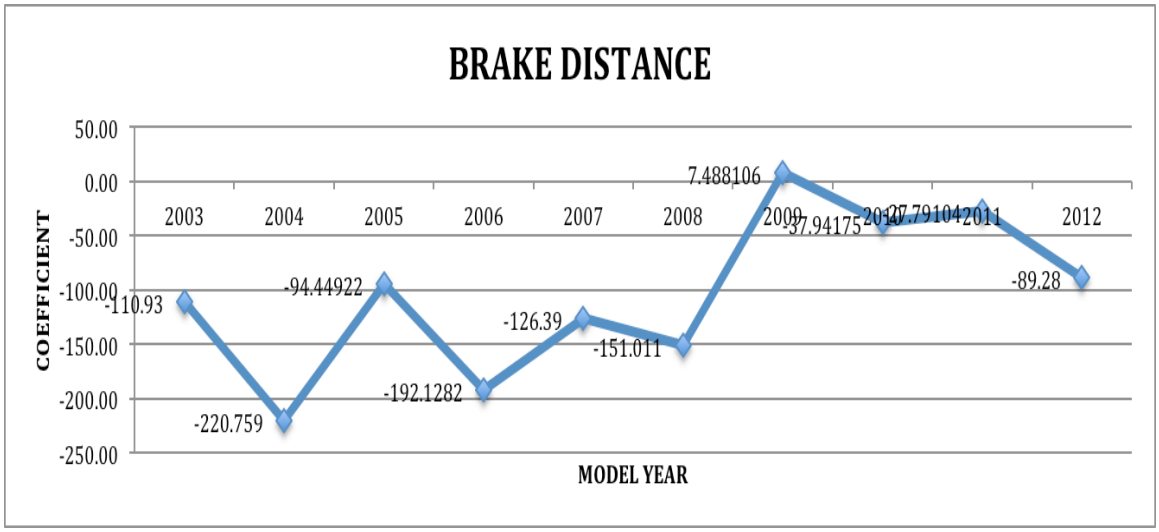


Figure 5.7 Sales-Weighted Means of Average Fuel Economy

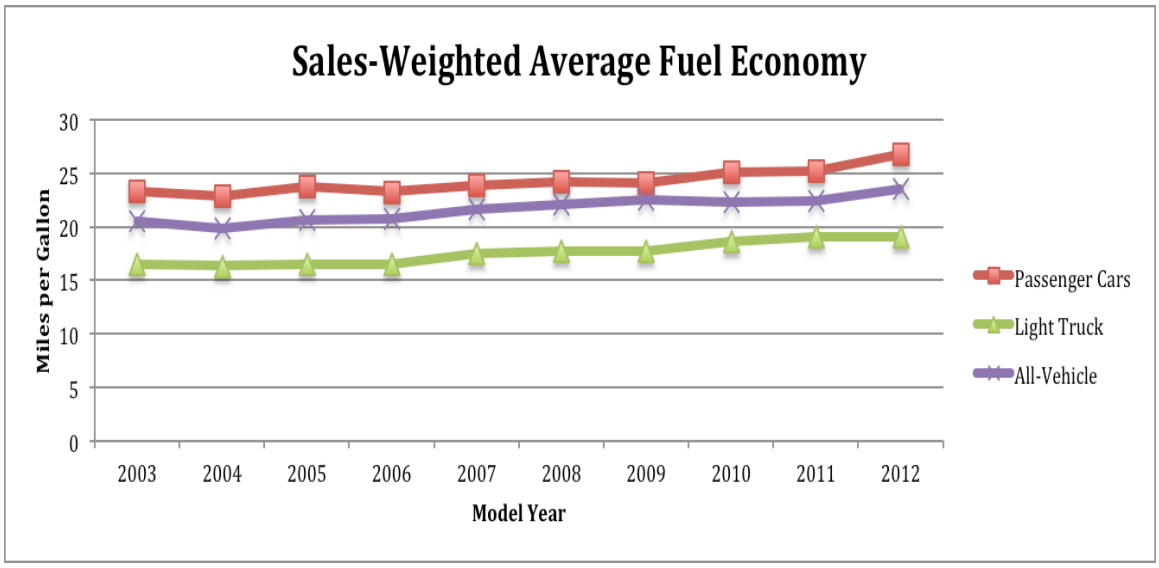


Figure 5.8 Sales-Weighted Means of City Fuel Economy

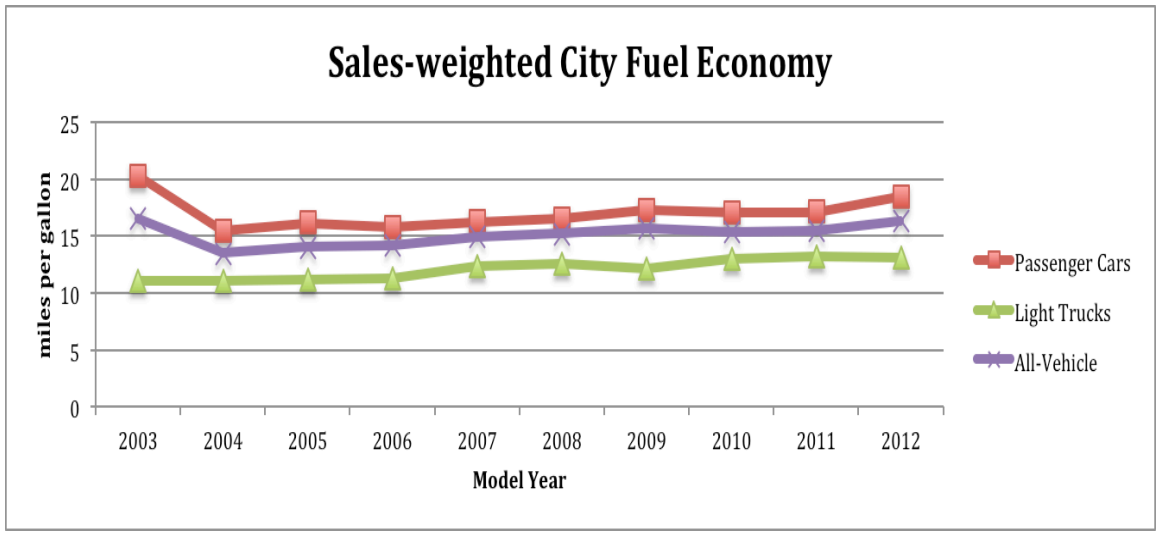


Figure 5.9 Sales-Weighted Means of Highway Fuel Economy

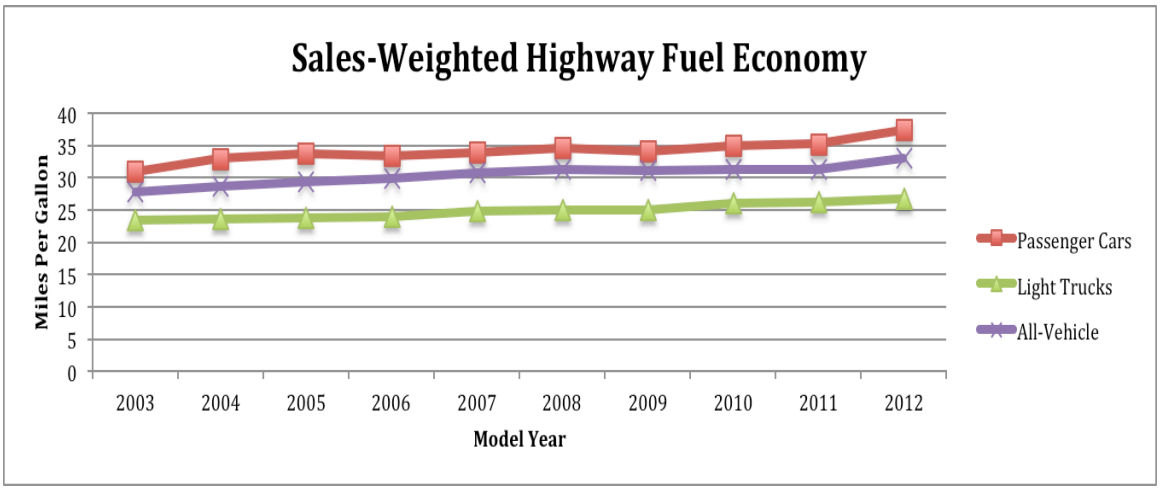
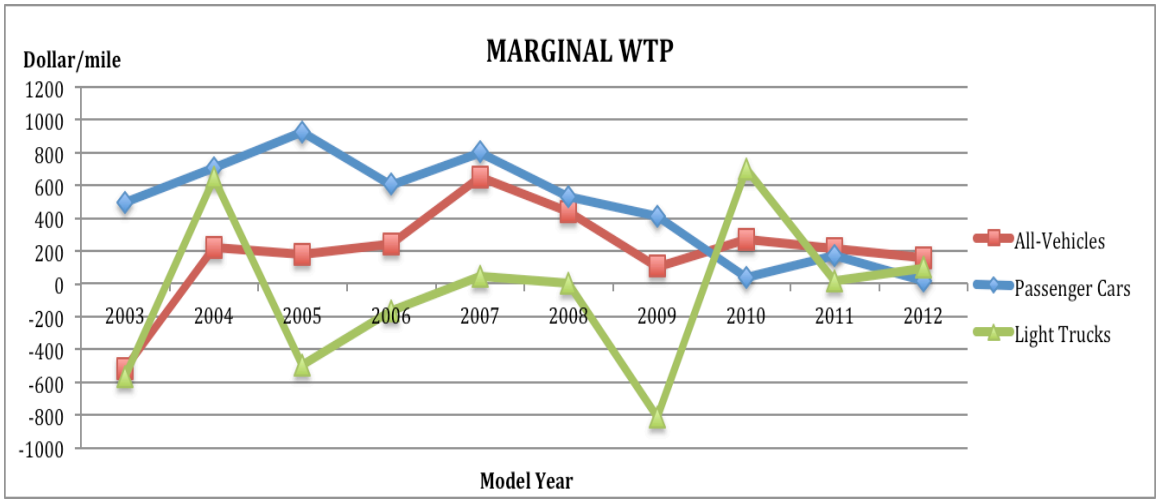


Figure 5.10 Marginal Willingness to Pay for 1-Mile Increase in Fuel Economy



Appendix B

TABLES

Table 3.1. Predicted Annual Vehicle Miles Traveled for All Vehicles by Model Year

Age	2001	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	14892	14892	14932.5	14760.72	14720.88	14158.32	13682.52	13851	14251.32	14034.32	14793.09
1	14892	14892	14932.5	14760.72	14720.88	14158.32	13682.52	13851	14251.32	14034.32	14793.09
2	14892	14892	14932.5	14760.72	14720.88	14158.32	13682.52	13851	14251.32	14034.32	14793.09
3	13230	13230	13260.06	13041.6	13006.4	12331.44	11902.68	12042	12412.44	12223.44	13070.2
4	13230	13230	13260.06	13041.6	13006.4	12331.44	11902.68	12042	12412.44	12223.44	13070.2
5	13230	13230	13260.06	13041.6	13006.4	12331.44	11902.68	12042	12412.44	12223.44	13070.2
6	11603	11603	11587.62	11500.32	11469.28	10961.28	10623.42	10741	11033.28	10865.28	11525.54
7	11603	11603	11587.62	11500.32	11469.28	10961.28	10623.42	10741	11033.28	10865.28	11525.54
8	11603	11603	11587.62	11500.32	11469.28	10961.28	10623.42	10741	11033.28	10865.28	11525.54
9	11603	11603	11587.62	11500.32	11469.28	10961.28	10623.42	10741	11033.28	10865.28	11525.54
10	7863	7863	7872.414	7813.104	7792.016	7524.462	7330.716	7401	7573.887	7458.562	7830.238
11	7863	7863	7872.414	7813.104	7792.016	7524.462	7330.716	7401	7573.887	7458.562	7830.238
12	7863	7863	7872.414	7813.104	7792.016	7524.462	7330.716	7401	7573.887	7458.562	7830.238
13	7863	7863	7872.414	7813.104	7792.016	7524.462	7330.716	7401	7573.887	7458.562	7830.238
14	-	-	-	1756.816	2190.816	7524.462	7330.716	7401	7573.887	7458.562	1404.816
15	-	-	-	-	-	1480.816	6514.816	4769.816	423.816	2890.816	-
Total	162230	162230	162417.8	162417.5	162417.8	162417.5	162417.7	162417.8	162417.7	162418.0	162417.8

Table 1: 2003 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24165.65	8246.245	9494	53915	129
Curb Weight (pounds)	3546.351	789.006	2035	5564	128
Acceleration (seconds)	9.217	1.461	4.9	14	129
Brake (feet)	140.338	7.537	117	166	129
Turning Circle (feet)	39.597	2.367	32.8	52	129
Front Crash Test Rating	4.34	0.647	3	5	120
Side Crash Test Rating	3.844	1.077	1	5	119
Reliability Rating	2.928	1.233	1	5	125
Comfort Rating	3.816	0.688	2	5	129
Average (mpg)	20.469	4.689	10	41	129
Highway (mpg)	27.85	5.565	13	54	129
City (mpg)	16.494	6.093	6	52	129
Light Duty Vehicles	0.416	0.495	0	1	129
Passenger Cars	0.584	0.495	0	1	129

Table 2: 2004 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	27457.65	8895.192	11290	74320	152
Curb Weight (pounds)	3644.347	731.849	1850	7190	147
Acceleration (seconds)	8.997	1.335	4.9	14	148
Turning Circle (feet)	40.013	2.275	33	52	148
Brake (feet)	140.086	8.228	117	166	148
Comfort Rating	3.889	0.651	2	5	148
Reliability Rating	3.18	1.238	1	5	124
Front Crash Test Rating	4.399	0.648	3	5	125
Side Crash Test Rating	4.134	1.007	1	5	121
City (mpg)	13.48	3.559	6	36	148
Highway (mpg)	28.707	6.242	13	66	148
Average (mpg)	19.9	4.774	10	51	148
Front Wheel Drive (FWD)	0.603	0.491	0	1	152
All Wheel Drive AWD	0.132	0.34	0	1	152
Four Wheel Drive (WD4)	0.148	0.356	0	1	152
Rear Wheel Drive RWD	0.117	0.322	0	1	152
Light Duty Vehicles	0.45	0.499	0	1	152
Passenger Cars	0.55	0.499	0	1	152

Table 3: 2005 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	28782.797	10057.001	11044	76020	154
Curb Weight (pounds)	3686.836	910.431	1619	7230	154
Acceleration (seconds)	8.673	1.481	5.100	12	147
Turning Circle (feet)	39.928	3.088	34	52	147
Brake (feet)	138.124	8.700	116	166	147
Comfort Rating	3.85	0.892	0	5	147
Reliability Rating	2.846	1.505	0	5	127
Average (mpg)	20.601	6.991	10	51	147
Highway (mpg)	29.386	8.567	13	66	147
City (mpg)	14.019	4.999	6	35	147
Front Wheel Drive (FWD)	0.537	0.5	0	1	154
All Wheel Drive (AWD)	0.194	0.397	0	1	154
Four Wheel Drive (WD4)	0.12	0.326	0	1	154
Rear Wheel Drive (RWD)	0.149	0.357	0	1	154
Passenger Cars	0.593	0.493	0	1	154
Light Duty Vehicles	0.407	0.493	0	1	154
Front Crash Test Rating	4.546	0.578	3	5	135
Side Crash Test Rating	4.179	0.867	1	5	135

Table 4: 2006 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	25608.934	8684.648	11110	76495	175
Curb Weight (pounds)	3560.877	688.542	1850	5555	174
Acceleration (seconds)	8.976	1.278	5	12.4	139
Turning Circle (feet)	39.58	2.171	33	44	139
Brake (feet)	139.002	7.351	112	155	139
Comfort Rating	3.577	1.15	1	5	144
Reliability Rating	3.148	1.212	1	5	145
Average (mpg)	20.776	5.014	12	51	139
Highway (mpg)	29.962	6.308	19	66	139
City (mpg)	14.144	3.905	8	36	139
Front Wheel Drive (FWD)	0.67	0.472	0	1	175
All Wheel Drive (AWD)	0.078	0.269	0	1	175
Four Wheel Drive (WD4)	0.018	0.133	0	1	175
Rear Wheel Drive (RWD)	0.234	0.425	0	1	175
Passenger Cars	0.621	0.487	0	1	175
Light Duty Vehicles	0.379	0.487	0	1	175
Front Crash Test Rating	4.775	0.423	3	5	147
Side Crash Test Rating	4.614	0.588	3	5	146

Table 5: 2007 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	25391.439	9592.884	10995	95575	157
Curb Weight (pounds)	3528.72	692.325	2293	5665	155
Acceleration (seconds)	8.801	1.311	4.4	12.8	156
Turning Circle (feet)	39.309	2.225	33	46	156
Brake (feet)	139.157	7.539	13	163	156
Comfort Rating	3.581	1.117	1	5	148
Reliability Rating	3.405	1.137	1	5	147
Average (mpg)	21.655	5.221	12	44	156
City (mpg)	14.92	4.15	8	35	156
Highway (mpg)	30.685	6.45	19	50	156
Front Wheel Drive (FWD)	0.729	0.446	0	1	157
All Wheel Drive (AWD)	0.057	0.233	0	1	157
Four Wheel Drive (WD4)	0.036	0.187	0	1	157
Rear Wheel Drive (RWD)	0.178	0.384	0	1	157
Passenger Cars	0.653	0.478	0	1	157
Light Duty Vehicles	0.347	0.478	0	1	157
Front Crash Test Rating	4.825	0.382	4	5	137
Side Crash Test Rating	4.684	0.528	3	5	131

Table 6: 2008 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	25142.961	9551.313	11395	103875	166
Curb Weight (pounds)	3496.854	707.506	2293	5920	162
Acceleration (seconds)	8.956	1.311	4.2	12.8	165
Turning Circle (feet)	39.196	2.3	33	46	165
Brake (feet)	139.626	7.514	112	163	164
Comfort Rating	3.666	1.1	1	5	166
Reliability Rating	3.49	1.087	1	5	166
Average (mpg)	22.051	5.315	12	44	163
City (mpg)	15.179	4.203	8	35	166
Highway (mpg)	31.224	6.617	17	50	166
Front Wheel Drive (FWD)	0.738	0.441	0	1	166
All Wheel Drive (AWD)	0.066	0.25	0	1	166
Four Wheel Drive (WD4)	0.013	0.114	0	1	166
Rear Wheel Drive (RWD)	0.182	0.387	0	1	166
Passenger Cars	0.653	0.478	0	1	166
Light Duty Vehicles	0.347	0.478	0	1	166
Front Crash Test Rating	4.822	0.384	4	5	151
Side Crash Test Rating	4.687	0.552	3	5	149

Table 7: 2009 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	26610.664	9948.504	11745	99375	175
Curb Weight (pounds)	3529.357	710.945	1808	6614	177
Acceleration (seconds)	8.887	1.226	4.2	14.6	177
Turning Circle (feet)	39.187	2.397	30	47	177
Brake (feet)	139.582	7.279	112	163	177
Comfort Rating	3.337	0.972	1	5	153
Reliability Rating	3.531	1.122	1	5	164
Average (mpg)	22.536	5.827	11	44	177
City (mpg)	15.638	4.726	7	35	177
Highway (mpg)	31.132	6.377	14	50	177
Front Wheel Drive (FWD)	0.771	0.422	0	1	182
All Wheel Drive (AWD)	0.081	0.274	0	1	182
Four Wheel Drive (WD4)	0.013	0.112	0	1	182
Rear Wheel Drive (RWD)	0.135	0.343	0	1	182
Passenger Cars	0.522	0.501	0	1	182
Light Duty Vehicles	0.334	0.473	0	1	182
Front Crash Test Rating	4.787	0.411	4	5	140
Side Crash Test Rating	4.861	0.349	3	5	131

Table 8: 2010 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	27278.103	9674.977	12685	111275	180
Curb Weight (pounds)	3576.576	697.734	1808	5854	179
Acceleration (seconds)	8.806	1.348	4.2	14.6	182
Turning Circle (feet)	39.398	2.293	30	47	182
Brake (feet)	137.632	6.187	113	158	182
Comfort Rating	3.689	0.919	1	5	182
Reliability Rating	3.49	1.131	1	5	182
Average (mpg)	22.316	5.28	13	44	180
City (mpg)	15.368	3.984	8	32	181
Highway (mpg)	31.191	6.423	18	55	181
Front Wheel Drive (FWD)	0.75	0.434	0	1	183
All Wheel Drive (AWD)	0.081	0.273	0	1	183
Four Wheel Drive (WD4)	0.016	0.126	0	1	183
Rear Wheel Drive (RWD)	0.154	0.361	0	1	183
Passenger Cars	0.574	0.496	0	1	183
Light Duty Vehicles	0.426	0.496	0	1	183
Front Crash Test Rating	4.845	0.363	4	5	167
Side Crash Test Rating	4.928	0.26	4	5	167

Table 9: 2011 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	27520.471	10426.037	10740	103475	182
Curb Weight (pounds)	3602.103	679.752	2306	5898	173
Acceleration (seconds)	8.815	1.314	4.3	12.8	182
Turning Circle (feet)	39.41	2.299	33	53.5	181
Brake (feet)	137.287	5.422	112	154	182
Comfort Rating	3.624	0.793	1	5	182
Reliability Rating	3.359	0.898	1	5	181
Average (mpg)	22.459	4.932	13	44	182
City (mpg)	15.432	3.742	8	32	180
Highway (mpg)	31.282	6.065	18	55	180
Front Wheel Drive (FWD)	0.774	0.42	0	1	182
All Wheel Drive (AWD)	0.056	0.231	0	1	182
Four Wheel Drive (WD4)	0.004	0.064	0	1	182
Rear Wheel Drive (RWD)	0.166	0.373	0	1	182
Passenger Cars	0.555	0.498	0	1	182
Light Duty Vehicles	0.445	0.498	0	1	182
Front Crash Test Rating	4.612	0.632	3	5	172
Side Crash Test Rating	4.67	0.63	2	5	172

Table 10: 2012 Summary Statistics for All Vehicles

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	28245.909	10577.583	13205	95375	179
Curb Weight (pounds)	3598.666	726.131	1808	5844	177
Acceleration (seconds)	8.686	1.255	5	14.6	183
Turning Circle (feet)	39.242	2.195	28	45	183
Brake (feet)	136.904	5.486	115	158	181
Reliability Rating	3.314	1.008	1	5	178
Comfort Rating	3.485	0.744	2	5	178
Average (mpg)	23.529	5.857	13	61	181
City (mpg)	16.287	4.365	8	45	177
Highway (mpg)	33.017	7.457	18	76	177
Front Wheel Drive (FWD)	0.754	0.432	0	1	183
Rear Wheel Drive (RWD)	0.151	0.359	0	1	183
All Wheel Drive (AWD)	0.072	0.26	0	1	183
Four Wheel Drive (WD4)	0.022	0.148	0	1	183
Passenger Cars	0.573	0.496	0	1	183
Light Duty Vehicles	0.427	0.496	0	1	183
Front Crash Test Rating	4.672	0.541	3	5	153
Side Crash Test Rating	4.797	0.52	2	5	153

Table 11: 2003 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	29323.203	7099.964	18435	53915	47
Curb Weight (pounds)	4191.435	750.713	2711	5564	46
Acceleration (seconds)	9.75	1.131	7.100	12.5	47
Brake (feet)	143.058	7.185	127	166	47
Turning Circle (feet)	40.282	2.21	37	52	47
Front Crash Test Rating	4.179	0.731	3	5	39
Side Crash Test Rating	4.665	0.695	2	5	38
Reliability Rating	2.701	1.349	1	5	43
Comfort Rating	3.715	0.64	2	5	47
Average (mpg)	16.518	2.482	10	22	47
Highway (mpg)	23.494	3.337	13	30	47
City (mpg)	11.107	1.814	6	16	47

Table 12: 2004 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	30503.376	7394.379	20290	54765	60
Curb Weight (pounds)	4229.428	630.763	3090	7190	57
Acceleration (seconds)	9.395	0.985	6.4	11.9	60
Turning Circle (feet)	40.714	2.262	37	52	60
Brake (feet)	143.105	7.726	127	166	60
Comfort Rating	3.815	0.601	2	5	60
Reliability Rating	2.978	1.364	1	5	51
Front Crash Test Rating	4.289	0.711	3	5	53
Side Crash Test Rating	4.843	0.378	2	5	47
City (mpg)	11.042	1.847	6	16	60
Highway (mpg)	23.592	3.444	13	30	60
Average (mpg)	16.332	2.553	10	22	60
Front Wheel Drive (FWD)	0.334	0.476	0	1	60
All Wheel Drive (AWD)	0.25	0.437	0	1	60
Four Wheel Drive (WD4)	0.329	0.474	0	1	60
Rear Wheel Drive (RWD)	0.087	0.284	0	1	60

Table 13: 2005 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	30979.789	8315.277	20515	55590	59
Curb Weight (pounds)	4353.41	875.797	3090	7230	59
Acceleration (seconds)	9.412	1.049	6.4	11.9	59
Turning Circle (feet)	41.182	3.183	37	52	59
Brake (feet)	141.64	8.75	127	166	59
Comfort Rating	3.541	1.123	0	5	59
Reliability Rating	2.462	1.67	0	5	59
Average (mpg)	16.527	2.763	10	21	59
Highway (mpg)	23.707	3.975	13	30	59
City (mpg)	11.185	2.13	6	15	59
Front Wheel Drive (FWD)	0.259	0.442	0	1	59
All Wheel Drive (AWD)	0.417	0.497	0	1	59
Four Wheel Drive (WD4)	0.293	0.459	0	1	59
Rear Wheel Drive (RWD)	0.03	0.172	0	1	59
Front Crash Test Rating	4.493	0.6	3	5	59
Side Crash Test Rating	4.503	0.877	1	5	59

Table 14: 2006 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	29602.105	7525.685	15990	74950	67
Curb Weight (pounds)	4206.827	543.952	3155	5555	66
Acceleration (seconds)	9.056	1.212	7.2	12.4	49
Turning Circle (feet)	40.509	1.978	37	44	49
Brake (feet)	141.73	8.07	130	155	49
Comfort Rating	3.153	1.161	1	5	56
Reliability Rating	2.626	1.233	1	5	57
Average (mpg)	16.456	2.522	12	25	49
Highway (mpg)	23.988	3.199	19	35	49
City (mpg)	11.28	2.101	8	20	49
Front Wheel Drive (FWD)	0.496	0.504	0	1	67
All Wheel Drive (AWD)	0.138	0.347	0	1	67
Four Wheel Drive (WD4)	0.047	0.213	0	1	67
Rear Wheel Drive (RWD)	0.319	0.47	0	1	67
Front Crash Test Rating	4.77	0.424	4	5	56
Side Crash Test Rating	4.978	0.149	4	5	53

Table 15: 2007 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	29498.417	7636.132	15985	55120	55
Curb Weight (pounds)	4170.015	591.918	3071	5665	55
Acceleration (seconds)	8.874	1.074	6.4	11.5	55
Turning Circle (feet)	40.073	2.034	33	45	55
Brake (feet)	140.132	7.679	121	158	55
Comfort Rating	3.21	1.046	1	5	51
Reliability Rating	3.199	1.327	1	5	51
Average (mpg)	17.54	2.905	12	23	55
City (mpg)	12.352	2.745	8	20	55
Highway (mpg)	24.798	3.51	19	33	55
Front Wheel Drive (FWD)	0.558	0.501	0	1	55
All Wheel Drive (AWD)	0.094	0.295	0	1	55
Four Wheel Drive (WD4)	0.103	0.307	0	1	55
Rear Wheel Drive (RWD)	0.244	0.433	0	1	55
Front Crash Test Rating	4.884	0.324	4	5	51
Side Crash Test Rating	4.959	0.2	4	5	45

Table 16: 2008 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	28820.258	8360.552	17035	56275	66
Curb Weight (pounds)	4154.662	677.459	3071	5920	63
Acceleration (seconds)	9.002	1.046	7.2	11.5	66
Turning Circle (feet)	40.203	2.158	36	45	66
Brake (feet)	141.467	7.869	128	158	65
Comfort Rating	3.402	1.06	1	5	66
Reliability Rating	3.451	1.255	1	5	66
Average (mpg)	17.746	3.095	12	24	64
City (mpg)	12.531	2.986	8	20	66
Highway (mpg)	24.958	3.765	17	33	66
Front Wheel Drive (FWD)	0.577	0.498	0	1	66
All Wheel Drive (AWD)	0.132	0.341	0	1	66
Four Wheel Drive (WD4)	0.038	0.192	0	1	66
Rear Wheel Drive (RWD)	0.253	0.438	0	1	66
Front Crash Test Rating	4.874	0.335	4	5	65
Side Crash Test Rating	4.923	0.389	3	5	63

Table 17: 2009 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	30984.405	8579.543	18795	63765	67
Curb Weight (pounds)	4122.584	694.039	3071	6614	70
Acceleration (seconds)	9.132	1.079	6.7	11.5	68
Turning Circle (feet)	40.439	1.924	36	45	68
Brake (feet)	143.015	8.906	128	161	68
Comfort Rating	2.952	1.014	1	5	61
Reliability Rating	2.98	1.238	1	5	68
Average (mpg)	17.726	2.583	11	24	68
City (mpg)	12.109	2.258	7	18	68
Highway (mpg)	24.997	2.983	14	31	68
Front Wheel Drive (FWD)	0.674	0.472	0	1	72
All Wheel Drive (AWD)	0.091	0.289	0	1	72
Four Wheel Drive (WD4)	0.036	0.188	0	1	72
Rear Wheel Drive (RWD)	0.199	0.402	0	1	72
Front Crash Test Rating	4.939	0.242	4	5	63
Side Crash Test Rating	4.963	0.191	4	5	59

Table 18: 2010 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	31549.956	8634.655	18425	65555	81
Curb Weight (pounds)	4102.105	646.384	3074	5854	81
Acceleration (seconds)	8.782	1.088	6.4	11.3	83
Turning Circle (feet)	40.649	2.019	36	45	83
Brake (feet)	139.343	7.173	126	158	83
Comfort Rating	3.605	0.753	1	5	83
Reliability Rating	3.105	1.233	1	5	83
Average (mpg)	18.573	2.928	13	26	82
City (mpg)	12.99	2.726	8	22	82
Highway (mpg)	26.047	3.299	18	32	82
Front Wheel Drive (FWD)	0.663	0.475	0	1	83
All Wheel Drive (AWD)	0.134	0.342	0	1	83
Four Wheel Drive (WD4)	0.037	0.191	0	1	83
Rear Wheel Drive (RWD)	0.165	0.374	0	1	83
Front Crash Test Rating	4.943	0.234	4	5	79
Side Crash Test Rating	4.973	0.163	4	5	79

Table 19: 2011 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	30898.734	8380.142	19750	68180	82
Curb Weight (pounds)	4039.847	665.458	2923	5898	77
Acceleration (seconds)	8.843	1.142	6.4	11	82
Turning Circle (feet)	40.427	2.048	36	45	81
Brake (feet)	138.359	5.594	126	154	82
Comfort Rating	3.704	0.71	2	5	82
Reliability Rating	3.326	0.969	1	5	82
Average (mpg)	19.047	2.608	13	26	82
City (mpg)	13.219	2.265	8	19	80
Highway (mpg)	26.295	3.127	18	33	80
Front Wheel Drive (FWD)	0.737	0.443	0	1	82
All Wheel Drive (AWD)	0.068	0.253	0	1	82
Four Wheel Drive (WD4)	0.009	0.096	0	1	82
Rear Wheel Drive (RWD)	0.186	0.392	0	1	82
Front Crash Test Rating	4.564	0.709	3	5	78
Side Crash Test Rating	4.64	0.627	3	5	78

Table 20: 2012 Summary Statistics for Light Trucks

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	32791.681	8778.302	20525	79685	82
Curb Weight (pounds)	4152.905	636.418	2923	5844	82
Acceleration (seconds)	8.576	1.092	6.4	11	82
Turning Circle (feet)	40.636	2.015	37	45	82
Brake (feet)	137.957	5.953	126	158	80
Reliability Rating	3.114	1.119	1	5	82
Comfort Rating	3.313	0.755	2	5	81
Average (mpg)	19.034	2.652	13	26	80
City (mpg)	13.131	2.151	8	19	77
Highway (mpg)	26.756	3.298	18	34	77
Front Wheel Drive (FWD)	0.700	0.461	0	1	82
Rear Wheel Drive (RWD)	0.151	0.36	0	1	82
All Wheel Drive (AWD)	0.097	0.298	0	1	82
Four Wheel Drive (WD4)	0.052	0.224	0	1	82
Front Crash Test Rating	4.564	0.609	3	5	70
Side Crash Test Rating	4.853	0.564	2	5	70

Table 21: 2003 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	20496.162	6969.852	9494	50745	82
Curb Weight (pounds)	3090.118	405.137	2035	4352	82
Acceleration (seconds)	8.839	1.555	4.9	14	82
Brake (feet)	138.403	7.221	117	151	82
Turning Circle (feet)	39.109	2.369	32.8	45	82
Front Crash Test Rating	4.437	0.575	3	5	81
Side Crash Test Rating	3.35	0.959	1	5	81
Reliability Rating	3.079	1.135	1	5	82
Comfort Rating	3.888	0.716	2	5	82
Average (mpg)	23.28	3.77	16	41	82
Highway (mpg)	30.949	4.69	25	54	82
City (mpg)	20.327	5.071	10	52	82

Table 22: 2004 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24963.504	9276.974	11290	74320	92
Curb Weight (pounds)	3199.1	427.315	1850	4464	90
Acceleration (seconds)	8.669	1.493	4.9	14	88
Turning Circle (feet)	39.433	2.13	33	45	88
Brake (feet)	137.591	7.827	117	154	88
Comfort Rating	3.951	0.688	2	5	88
Reliability Rating	3.347	1.107	1	5	73
Front Crash Test Rating	4.491	0.58	3	5	72
Side Crash Test Rating	3.629	1.011	1	5	74
City (mpg)	15.494	3.372	10	36	88
Highway (mpg)	32.932	4.671	22	66	88
Average (mpg)	22.848	4.127	16	51	88
Front Wheel Drive (FWD)	0.823	0.384	0	1	92
All Wheel Drive (AWD)	0.036	0.188	0	1	92
Rear Wheel Drive (RWD)	0.141	0.35	0	1	92

Table 23: 2005 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	27271.928	10885.4	11044	76020	95
Curb Weight (pounds)	3228.434	599.48	1619	4464	95
Acceleration (seconds)	8.111	1.519	5.100	12	88
Turning Circle (feet)	38.971	2.658	34	45	88
Brake (feet)	135.443	7.692	116	154	88
Comfort Rating	4.085	0.567	3	5	88
Reliability Rating	3.24	1.205	1	5	68
Average (mpg)	23.709	7.627	16	51	88
Highway (mpg)	33.718	8.609	22	66	88
City (mpg)	16.182	5.468	10	35	88
Front Wheel Drive (FWD)	0.728	0.447	0	1	95
All Wheel Drive (AWD)	0.041	0.199	0	1	95
Rear Wheel Drive (RWD)	0.231	0.424	0	1	95
Front Crash Test Rating	4.59	0.560	3	5	76
Side Crash Test Rating	3.913	0.767	2	5	76

Table 24: 2006 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	23171.65	8467.768	11110	76495	108
Curb Weight (pounds)	3167.27	416.478	1850	4552	108
Acceleration (seconds)	8.93	1.319	5	12	90
Turning Circle (feet)	39.048	2.107	33	44	90
Brake (feet)	137.441	6.451	112	153	90
Comfort Rating	3.804	1.084	1	5	88
Reliability Rating	3.439	1.104	1	5	88
Average (mpg)	23.248	4.37	16	51	90
Highway (mpg)	33.38	4.955	25	66	90
City (mpg)	15.783	3.756	10	36	90
Front Wheel Drive (FWD)	0.776	0.419	0	1	108
All Wheel Drive (AWD)	0.041	0.2	0	1	108
Rear Wheel Drive (RWD)	0.183	0.388	0	1	108
Front Crash Test Rating	4.779	0.425	3	5	91
Side Crash Test Rating	4.4	0.643	3	5	93

Table 25: 2007 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	23205.574	9840.054	10995	95575	102
Curb Weight (pounds)	3163.065	430.431	2293	4486	100
Acceleration (seconds)	8.76	1.428	4.4	12.8	101
Turning Circle (feet)	38.892	2.224	33	46	101
Brake (feet)	138.624	7.446	13	163	101
Comfort Rating	3.78	1.109	1	5	97
Reliability Rating	3.517	1.009	1	5	96
Average (mpg)	23.86	4.843	16	44	101
City (mpg)	16.296	4.13	10	35	101
Highway (mpg)	33.839	5.363	24	50	101
Front Wheel Drive (FWD)	0.819	0.387	0	1	102
All Wheel Drive (AWD)	0.037	0.191	0	1	102
Rear Wheel Drive (RWD)	0.143	0.352	0	1	102
Front Crash Test Rating	4.793	0.408	4	5	86
Side Crash Test Rating	4.551	0.585	3	5	86

Table 26: 2008 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	23185.269	9601.795	11395	103875	100
Curb Weight (pounds)	3157.889	430.206	2293	4486	99
Acceleration (seconds)	8.931	1.437	4.2	12.8	99
Turning Circle (feet)	38.658	2.199	33	46	99
Brake (feet)	138.644	7.161	112	163	99
Comfort Rating	3.807	1.1	1	5	100
Reliability Rating	3.511	0.991	1	5	100
Average (mpg)	24.233	4.859	15	44	99
City (mpg)	16.589	4.085	10	35	100
Highway (mpg)	34.56	5.245	24	50	100
Front Wheel Drive (FWD)	0.824	0.383	0	1	100
All Wheel Drive (AWD)	0.032	0.176	0	1	100
Rear Wheel Drive (RWD)	0.144	0.353	0	1	100
Front Crash Test Rating	4.793	0.407	4	5	86
Side Crash Test Rating	4.562	0.586	3	5	86

Table 27: 2009 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24481.068	9903.297	11745	99375	108
Curb Weight (pounds)	3235.918	508.49	1808	5730	107
Acceleration (seconds)	8.769	1.278	4.2	14.6	109
Turning Circle (feet)	38.584	2.375	30	47	109
Brake (feet)	137.928	5.682	112	163	109
Comfort Rating	3.528	0.896	1	5	92
Reliability Rating	3.807	0.950	1	5	96
Average (mpg)	24.854	5.534	14	44	109
City (mpg)	17.339	4.668	10	35	109
Highway (mpg)	34.089	5.394	20	50	109
Front Wheel Drive (FWD)	0.819	0.387	0	1	110
All Wheel Drive (AWD)	0.077	0.267	0	1	110
Four Wheel Drive (WD4)	0.001	0.03	0	1	110
Rear Wheel Drive (RWD)	0.104	0.306	0	1	110
Front Crash Test Rating	4.707	0.458	4	5	77
Side Crash Test Rating	4.808	0.399	3	5	72

Table 28: 2010 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24166.581	9226.987	12685	111275	99
Curb Weight (pounds)	3191.803	433.697	1808	5004	98
Acceleration (seconds)	8.822	1.518	4.2	14.6	99
Turning Circle (feet)	38.468	2.033	30	47	99
Brake (feet)	136.36	5.004	113	153	99
Comfort Rating	3.751	1.024	1	5	99
Reliability Rating	3.777	0.958	1	5	99
Average (mpg)	25.085	4.918	15	44	98
City (mpg)	17.106	3.867	10	32	99
Highway (mpg)	34.95	5.475	24	55	99
Front Wheel Drive (FWD)	0.814	0.391	0	1	100
All Wheel Drive (AWD)	0.041	0.199	0	1	100
Rear Wheel Drive (RWD)	0.145	0.354	0	1	100
Front Crash Test Rating	4.772	0.422	4	5	88
Side Crash Test Rating	4.894	0.309	4	5	88

Table 29: 2011 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24809.494	11131.937	10740	103475	100
Curb Weight (pounds)	3247.487	445.59	2306	4641	96
Acceleration (seconds)	8.791	1.442	4.3	12.8	100
Turning Circle (feet)	38.609	2.173	33	53.5	100
Brake (feet)	136.427	5.148	112	153	100
Comfort Rating	3.561	0.853	1	5	100
Reliability Rating	3.386	0.841	1	5	99
Average (mpg)	25.198	4.645	17	44	100
City (mpg)	17.16	3.764	11	32	100
Highway (mpg)	35.178	4.82	25	55	100
Front Wheel Drive (FWD)	0.803	0.4	0	1	100
All Wheel Drive (AWD)	0.047	0.212	0	1	100
Rear Wheel Drive (RWD)	0.15	0.359	0	1	100
Front Crash Test Rating	4.65	0.563	3	5	94
Side Crash Test Rating	4.694	0.634	2	5	94

Table 30: 2012 Summary Statistics for Passenger Cars

Variable	Mean	Std. Dev.	Min.	Max.	N
Retailprice (dollar)	24751.57	10551.124	13205	95375	97
Curb Weight (pounds)	3163.202	439.226	1808	4740	95
Acceleration (seconds)	8.768	1.363	5	14.6	101
Turning Circle (feet)	38.203	1.695	28	43	101
Brake (feet)	136.147	5.018	115	149	101
Reliability Rating	3.473	0.883	1	5	96
Comfort Rating	3.621	0.71	2	5	97
Average (mpg)	26.755	5.385	17	61	101
City (mpg)	18.457	4.177	11	45	100
Highway (mpg)	37.32	6.392	25	76	100
Front Wheel Drive (FWD)	0.795	0.406	0	1	101
Rear Wheel Drive (RWD)	0.151	0.36	0	1	101
All Wheel Drive (AWD)	0.054	0.227	0	1	101
Front Crash Test Rating	4.756	0.468	3	5	83
Side Crash Test Rating	4.754	0.482	3	5	83

Table 31: Average Fuel Economy Empirical Results of Weighted Least Squares of All-Vehicles

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	11.89***	10.31***	11.92***	9.325***	10.01***	10.58***	11.25***	8.367***	11.09***	5.667**
	[7.04]	[4.88]	[6.90]	[5.36]	[8.02]	[5.96]	[6.91]	[4.31]	[6.50]	[3.03]
Acceleration	-2024.6***	-2223.4***	-1529.0***	-2051.5***	-1821.1***	-1668.9***	-1760.0***	-2233.6***	-1229.2***	-627.6
	[-4.55]	[-4.52]	[-3.63]	[-3.45]	[-6.14]	[-5.32]	[-4.64]	[-4.39]	[-4.17]	[-1.69]
Turning Circle	-339.9	-214.1	-183.4	384.1	229.9	377.5	-145.2	-176.1	27.22	140.2
	[-1.15]	[-0.64]	[-0.71]	[1.65]	[1.06]	[1.74]	[-0.62]	[-0.55]	[0.11]	[0.51]
Brake	-27.79	-89.28	-37.94	7.488	-151.0**	-126.4*	-192.1**	-94.45	-220.8***	-110.9
	[-0.30]	[-1.02]	[-0.51]	[0.08]	[-2.99]	[-2.20]	[-3.17]	[-1.01]	[-3.70]	[-1.76]
Comfort	1061.4*	916	202.3	366.4	343.3	556.9	-952.3*	910.5	1304.2	28.64
	[2.09]	[1.04]	[0.38]	[0.86]	[0.91]	[1.21]	[-2.36]	[0.84]	[1.69]	[0.04]
Reliability	-244.9	766.2	244.8	77.38	461.3	350.7	1778.0***	-1143.2*	-655.8	304.1
	[-0.41]	[1.50]	[0.51]	[0.22]	[1.22]	[0.79]	[4.45]	[-2.19]	[-1.69]	[0.71]
avg_gpm	-1051.2	-834.6	-1279.7	-509	-2014.4**	-2893.0*	-989.3	-204.3	-2163.9*	2063.1*
	[-0.79]	[-0.48]	[-1.06]	[-0.46]	[-3.03]	[-2.20]	[-1.50]	[-0.16]	[-2.21]	[2.01]
light	-2142	-777.6	-1434.1	936.8	-1102.1	-330.1	-1776.5	-1813.9	-3578.4	-2520.5
	[-1.69]	[-0.58]	[-1.09]	[0.71]	[-1.01]	[-0.22]	[-1.16]	[-0.86]	[-1.76]	[-1.35]
FCT	-1555.2	-199.3	-1116.4	-2829.5**	-239.2	1078.4	-1410.9	-3553.7**	-1190.4	-377.8
	[-1.63]	[-0.29]	[-0.69]	[-2.66]	[-0.24]	[1.01]	[-1.26]	[-2.82]	[-1.64]	[-0.46]
SCT	772	852.6	-1081	-524.4	-442.8	-250.2	285.6	1438.6	598.4	1302.0**
	[0.96]	[0.99]	[-0.75]	[-0.56]	[-0.51]	[-0.32]	[0.48]	[1.70]	[1.23]	[2.80]
AWD	3933.4**	3500.5**	1241.7	2071.3	6217.7***	4286.6	4584.3**	2521.3	2926.9*	
	[2.63]	[2.76]	[0.82]	[1.40]	[4.17]	[1.66]	[3.09]	[1.54]	[2.06]	
RWD	2972.8	1940.2	2945.6	1072	3338.9*	4758.6**	1699.9	1860.7	4023.6*	
	[1.53]	[0.92]	[1.69]	[0.50]	[2.30]	[2.66]	[1.30]	[0.66]	[2.20]	
WD4	5168.1	6795.3	6344.4	-4815.6	1387.1	3421.2	5169.7**	-1810	2317	
	[1.68]	[1.77]	[1.79]	[-1.70]	[0.50]	[1.68]	[3.29]	[-0.73]	[1.53]	
_cons	25402.2	25305.7	25398.7	12006.1	27388.2*	10950.9	41878.7**	47800.1**	38505.2**	5492.2
	[1.94]	[1.57]	[1.73]	[0.82]	[2.28]	[0.92]	[2.92]	[2.77]	[3.13]	[0.45]
N	161	143	159	109	143	123	106	117	102	117
R-Squared	0.7455	0.749	0.7481	0.8208	0.816	0.7465	0.791	0.7319	0.7541	0.6894

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

Table 32: Average Fuel Economy Empirical Results of Weighted Least Squares of Passenger Cars

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	13.19***	19.53***	14.86***	11.88***	11.51***	10.80***	16.44***	17.64***	18.31***	15.13***
	[3.49]	[5.75]	[4.88]	[5.51]	[5.44]	[3.71]	[7.20]	[5.28]	[6.80]	[6.19]
Acceleration	-682.6	-1276.2	-229.5	-2063.7**	-1503.1***	-1256.1**	-1835.6***	454.2	-1262.1***	-846.9*
	[-0.89]	[-1.98]	[-0.39]	[-3.11]	[-4.51]	[-3.06]	[-3.66]	[0.69]	[-3.68]	[-2.11]
Turning Circle	-230.4	-753.2	-74.44	498.4	421	918.5*	-285.2	180.1	-705.6**	-125.5
	[-0.48]	[-1.59]	[-0.20]	[1.71]	[1.17]	[2.18]	[-0.78]	[0.59]	[-2.83]	[-0.49]
Brake	-68.24	-31.11	-102.2	-108.5	-125.6	-112.5	-240.9**	-151.8*	-179.1*	-107.5
	[-0.54]	[-0.23]	[-0.97]	[-1.07]	[-1.82]	[-1.54]	[-3.10]	[-2.12]	[-2.64]	[-1.83]
Comfort	634.2	509.4	20.92	-220.5	11.35	541.6	-1037.7*	3740.3**	864.7	-25.78
	[0.49]	[0.67]	[0.03]	[-0.40]	[0.02]	[1.12]	[-2.10]	[2.99]	[0.98]	[-0.03]
Reliability	737.6	-207.1	1186.8	33.9	858.3	392.1	1546.8**	-1832.3**	-609.4	-595.6
	[0.87]	[-0.24]	[1.41]	[0.09]	[1.64]	[0.64]	[2.79]	[-2.73]	[-1.10]	[-1.34]
avg_gpm	-121.7	-1076.5	-239.3	-2346.3	-3053.4**	-4455.0*	-3233.0***	-4783.0*	-3667.8**	-2689.8
	[-0.05]	[-0.59]	[-0.14]	[-1.48]	[-2.91]	[-2.10]	[-3.57]	[-2.60]	[-2.72]	[-1.83]
FCT	-1706.2	-1127.3	-2322.1	-3504.3**	-90.94	41.94	-1196.8	-3243.6*	-1457	-60.53
	[-1.52]	[-0.79]	[-1.11]	[-3.08]	[-0.09]	[0.04]	[-0.97]	[-2.37]	[-1.30]	[-0.07]
SCT	560.4	-299.3	-2082.2	-2031.3*	-668.8	-257.8	-656.7	1408.2	744.6	1790.9***
	[0.59]	[-0.25]	[-1.16]	[-2.48]	[-0.62]	[-0.29]	[-1.07]	[1.66]	[1.35]	[3.44]
AWD	1079.9	1812.4	-449.5	2443	3792.2	1035.1	4865.8*	5153.1	-723.1	
	[0.49]	[0.77]	[-0.24]	[1.71]	[1.23]	[0.29]	[2.10]	[1.59]	[-0.50]	
RWD	5253.6	2571.1	5741.8*	4583.1	6410.3**	8953.2***	1017.1	3291.8	862.9	
	[1.59]	[0.73]	[2.01]	[1.42]	[3.07]	[3.60]	[0.50]	[1.19]	[0.35]	
WD4				1850.3						
				[0.75]						
_cons	7136.6	15604.8	12279.6	35630.8*	13111.7	-5054.5	52624.2**	-766.8	48489.6***	8936.8
	[0.26]	[0.66]	[0.55]	[2.28]	[0.89]	[-0.31]	[3.22]	[-0.06]	[3.79]	[0.71]
N	75	89	84	63	84	80	69	58	63	81
R-Squared	0.7053	0.7531	0.6931	0.8341	0.7823	0.7624	0.7842	0.8352	0.8324	0.757

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

Table 33: Average Fuel Economy Empirical Results of Weighted Least Squares of Light Trucks

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	6.870**	8.238***	10.77***	5.504	7.494***	9.102**	7.939***	6.092**	6.072*	4.271**
	[3.17]	[4.32]	[4.83]	[1.76]	[3.70]	[3.41]	[3.93]	[2.71]	[2.36]	[3.34]
Acceleration	-2694.9***	-1426.3**	-2428.4***	-1909.5	-1919.2*	-1845.9*	-615.8	-2996.0***	-2108.4**	-1936.9**
	[-5.39]	[-3.02]	[-4.34]	[-1.87]	[-2.31]	[-2.74]	[-0.89]	[-3.73]	[-2.86]	[-3.13]
Turning Circle	-88.05	201.1	-332.6	1629.1*	326	272.3	230.6	-630.3	1076.1*	687.2
	[-0.26]	[0.63]	[-0.90]	[2.30]	[0.94]	[1.02]	[0.55]	[-1.14]	[2.50]	[1.86]
Brake	132.6	45.78	69.04	23.05	-76.73	-52.91	-144.2	-86.78	-23.61	-75.03
	[1.05]	[0.44]	[0.57]	[0.26]	[-0.93]	[-0.57]	[-1.09]	[-0.45]	[-0.16]	[-0.51]
Comfort	1886.8	1466.6*	-282.9	-190.8	1066.9	-91.44	-143.5	-555.3	752.6	-314.6
	[1.59]	[2.28]	[-0.31]	[-0.16]	[1.27]	[-0.09]	[-0.17]	[-0.37]	[0.63]	[-0.18]
Reliability	845.1	-131.7	-344.8	1325	306.1	1042.3	2397.7*	-1214.6	-97.05	916.7
	[1.45]	[-0.19]	[-0.57]	[1.33]	[0.42]	[1.36]	[2.76]	[-1.87]	[-0.18]	[1.55]
avg_gpm	-362.3	-64.52	-2425.5	2600.2	-17.71	-134.2	455.1	1354.3	-1745.9	1557.8
	[-0.23]	[-0.04]	[-1.68]	[1.43]	[-0.02]	[-0.05]	[0.42]	[0.61]	[-0.90]	[1.79]
FCT	793.2	-1073.9	2307.8	1020.2	-1493.4	774.1	788.7	-3198.3*	-739.3	-1013.9
	[0.89]	[-1.15]	[1.95]	[0.35]	[-0.74]	[0.35]	[0.34]	[-2.05]	[-0.70]	[-1.02]
SCT	4985.1**	1008.3	-2733.8	7526.2*	-702.9	-2154.7	8682.8	1398.8	-4059.7**	-1322.8
	[3.28]	[1.08]	[-0.65]	[2.72]	[-0.41]	[-0.82]	[2.03]	[0.91]	[-2.94]	[-1.49]
AWD	5046.3**	6362.0*	1061	6527.8**	7422.7***	7012.9**	5507.3*	2950.3	6417.3**	
	[2.95]	[2.35]	[0.46]	[2.77]	[3.78]	[2.91]	[2.67]	[1.70]	[3.04]	
RWD	-603.5	452.2	1006.8	-1920.7	-738.6	-1526.7	2158.7	-1379.3	3585.5	
	[-0.26]	[0.20]	[0.47]	[-0.64]	[-0.33]	[-0.45]	[1.15]	[-0.30]	[1.24]	
WD4	13355.1***	10340.4**	8059.2*	-9118.7*	840.7	-739.7	10260.8**	-1937.9	5042.4*	
	[4.48]	[2.99]	[2.14]	[-2.08]	[0.27]	[-0.26]	[2.82]	[-0.70]	[2.34]	
_cons	-23712.9	-9465.3	29315.8	-103907.2**	18148.7	8669.7	-44618.9	74845.1**	10411.1	12280
	[-1.04]	[-0.60]	[1.05]	[-2.86]	[0.82]	[0.26]	[-0.98]	[3.38]	[0.35]	[0.40]
N	68	72	75	46	59	43	37	59	39	36
R-Squared	0.793	0.8035	0.7923	0.8156	0.8266	0.7441	0.7403	0.7159	0.7624	0.718

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

Table 34: City-Highway Fuel Economy Empirical Results of Weighted Least Squares of All-Vehicles

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	11.00***	11.69***	11.81***	9.439***	10.19***	9.813***	11.17***	9.639***	10.74***	5.791**
	[4.97]	[6.69]	[7.08]	[5.42]	[8.00]	[7.05]	[7.01]	[4.51]	[6.46]	[2.91]
Acceleration	-2224.0***	-2009.3***	-1596.0***	-2099.6***	-1843.7***	-1779.5***	-1779.7***	-2222.7***	-1153.0***	-690.2
	[-4.44]	[-4.36]	[-4.00]	[-3.49]	[-6.24]	[-5.42]	[-4.67]	[-4.33]	[-4.07]	[-1.75]
Turning Circle	-192	-352.3	-269.2	371.4	231.4	368.1	-144.6	-99.99	-89.11	214.7
	[-0.55]	[-1.19]	[-1.13]	[1.53]	[1.08]	[1.61]	[-0.62]	[-0.32]	[-0.36]	[0.76]
Brake	-73.48	-30.1	-51.82	8.254	-130.1**	-144.1*	-199.3**	-78.15	-208.2***	-98.34
	[-0.81]	[-0.32]	[-0.69]	[0.09]	[-2.62]	[-2.26]	[-3.17]	[-0.79]	[-3.48]	[-1.52]
Comfort	522.9	1062.5*	109.1	271.7	198.7	556.6	-942.2*	667.9	1285.9	47.03
	[0.61]	[2.09]	[0.20]	[0.60]	[0.53]	[1.09]	[-2.48]	[0.61]	[1.66]	[0.07]
Reliability	494.2	-228.5	267.7	195.4	555.2	201.1	1745.0***	-1131.9*	-737.8	190.7
	[1.04]	[-0.39]	[0.56]	[0.49]	[1.56]	[0.44]	[4.23]	[-2.16]	[-1.87]	[0.43]
City_gpm	-508	-258.4	179.7	36.53	-759.4	-833.8	-157.9	-562.9	-224.5	646.6
	[-0.50]	[-0.32]	[0.28]	[0.06]	[-1.67]	[-1.34]	[-0.24]	[-0.56]	[-0.32]	[1.17]
Highway_gpm	-742.3	-789.9	-2783.1	-1441.8	-2000.5	-2489.9*	-1398.6	-947.8	-1335	1029.9
	[-0.41]	[-0.44]	[-1.70]	[-0.83]	[-1.79]	[-2.04]	[-0.83]	[-0.39]	[-1.33]	[0.78]
fct	-333.4	-1560.5	-1328	-2874.9**	-430.3	1275.9	-1464.6	-3524.9**	-1298.1	-223.2
	[-0.46]	[-1.63]	[-0.83]	[-2.74]	[-0.44]	[1.25]	[-1.31]	[-2.82]	[-1.62]	[-0.26]
sct	824.3	766.6	-1209.6	-611.2	-398.5	-396.2	190.3	1370.7	724.2	1486.6**
	[0.96]	[0.95]	[-0.86]	[-0.64]	[-0.46]	[-0.51]	[0.28]	[1.35]	[1.50]	[2.81]
light	-633.7	-2082	-407.8	1468.7	-378.5	333.6	-1409.1	-1399.6	1225.4	-3034.8
	[-0.48]	[-1.36]	[-0.30]	[0.98]	[-0.32]	[0.20]	[-0.80]	[-0.60]	[0.23]	[-1.51]
AWD	3482.2*	4060.8*	1749.6	2293.8	6412.7***	4472	4630.6**	2693.3	2137.7	
	[2.59]	[2.60]	[1.16]	[1.55]	[4.30]	[1.88]	[3.14]	[1.34]	[1.39]	
RWD	1791.5	3040.2	3262.5	1467	3964.5**	4418.8*	1815.4	3099.8	3249.3	
	[0.84]	[1.50]	[1.74]	[0.64]	[2.71]	[2.52]	[1.37]	[1.03]	[1.80]	
WD4	6324.5	5610.1	7265.0*	-3946.3	1362.6	3811.9*	5874.4**	-1049.8	1589	
	[1.59]	[1.84]	[2.06]	[-1.39]	[0.51]	[2.03]	[3.21]	[-0.37]	[1.10]	
_cons	24939.2	26232.5	35154.7*	14886.7	27005.2*	17803.1	44946.3**	45102.8*	38243.4**	2283.1
	[1.38]	[1.87]	[2.36]	[0.93]	[2.31]	[1.36]	[2.87]	[2.56]	[3.08]	[0.18]
N	140	161	160	109	144	123	106	117	102	117
R-Squared	0.7596	0.7451	0.7538	0.8222	0.8208	0.7525	0.7921	0.7377	0.7526	0.6855

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

Table 35: City-Highway Fuel Economy Empirical Results of Weighted Least Squares of Passenger Cars

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	12.93**	21.64***	15.55***	11.44***	11.06***	10.25***	16.29***	15.79***	18.85***	14.47***
	[3.42]	[5.10]	[4.71]	[5.61]	[4.78]	[3.72]	[7.69]	[4.62]	[6.00]	[6.14]
Acceleration	-628.7	-660	-225.8	-2201.4**	-1610.0***	-1261.1**	-1862.1***	291.4	-1186.4**	-1205.5**
	[-0.76]	[-0.95]	[-0.35]	[-3.23]	[-4.00]	[-2.66]	[-3.85]	[0.36]	[-3.30]	[-2.73]
Turning Circle	-257.1	-669.4	-72.7	414	410.7	879.2*	-220	102.1	-783.2**	-24.78
	[-0.47]	[-1.46]	[-0.20]	[1.35]	[1.12]	[2.08]	[-0.59]	[0.30]	[-3.13]	[-0.09]
Brake	-81.21	-23.67	-92.66	-96.63	-122.8	-116.1	-253.6**	-151.9	-167.3*	-151.4**
	[-0.63]	[-0.18]	[-0.87]	[-0.95]	[-1.81]	[-1.60]	[-3.41]	[-1.99]	[-2.55]	[-2.70]
Comfort	688.8	817.9	-43.81	-242.9	-48.14	598.4	-985.4*	3932.2**	796.5	89.49
	[0.50]	[1.06]	[-0.06]	[-0.41]	[-0.09]	[1.10]	[-2.15]	[3.14]	[0.86]	[0.12]
Reliability	782.5	-45.94	1207.5	293.1	835.8	274.7	1418.2*	-1902.8**	-514.3	-796.6
	[0.93]	[-0.05]	[1.50]	[0.91]	[1.62]	[0.43]	[2.52]	[-2.86]	[-0.88]	[-1.74]
City_gpm	117.4	-2284.1	-615.3	-162.3	-1005.3	-2068.9	-1181.8*	-867.1	-1599.8	-348.3
	[0.07]	[-1.77]	[-0.52]	[-0.17]	[-1.43]	[-1.59]	[-2.21]	[-0.77]	[-1.26]	[-0.68]
Highway_gpm	99.14	5184.6	467.7	-3462.4	-2583.2	-1178.4	-2700.2	-4049.1	-1736.9	-4731.4**
	[0.03]	[1.57]	[0.16]	[-1.58]	[-1.05]	[-0.54]	[-1.71]	[-1.29]	[-0.55]	[-2.99]
fct	-1742.6	-971.8	-2062.7	-3717.8**	-162.3	280.3	-1302.7	-3561.2*	-1542	10.88
	[-1.49]	[-0.78]	[-0.97]	[-3.26]	[-0.15]	[0.28]	[-1.10]	[-2.61]	[-1.38]	[0.01]
sct	604.4	-399.3	-2151.7	-1978.1*	-569.5	-208.9	-778.4	1214.4	835.5	1979.0***
	[0.64]	[-0.33]	[-1.15]	[-2.42]	[-0.51]	[-0.25]	[-1.20]	[1.10]	[1.43]	[3.56]
AWD	980.1	-386.3	-745.5	2345.3	4425.9	1242.4	5355.7*	5057.2	-1238.2	
	[0.40]	[-0.13]	[-0.35]	[1.75]	[1.42]	[0.37]	[2.35]	[1.40]	[-0.57]	
RWD	5188.8	2204.4	5974.7*	4441.4	6531.6**	8513.1**	1331.7	3465.3	560.6	
	[1.56]	[0.65]	[2.16]	[1.33]	[3.14]	[3.36]	[0.66]	[1.00]	[0.21]	
WD4				4981						
				[1.56]						
_cons	8498.8	-8228.4	9330.8	41272.7*	16612.9	-4780.9	55508.0**	8128.1	47218.1***	21112.2
	[0.26]	[-0.34]	[0.38]	[2.59]	[1.02]	[-0.25]	[3.32]	[0.41]	[3.65]	[1.81]
N	75	89	85	63	84	80	69	58	63	81
R-Squared	0.7054	0.765	0.694	0.84	0.7843	0.7683	0.7929	0.8295	0.8343	0.7736

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

Table 36: City-Highway Fuel Economy Empirical Results of Weighted Least Squares of Light Trucks

Variable	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Curb Weight	8.353***	7.911***	9.894***	6.22	7.960***	9.757***	8.196***	7.333*	5.563	4.092**
	[4.06]	[4.30]	[4.04]	[1.81]	[3.99]	[4.92]	[3.99]	[2.65]	[1.98]	[3.06]
Acceleration	-2593.7***	-1430.8**	-2361.7***	-1886.6	-1965.2*	-1742.8*	-654.7	-3223.6***	-2021.4*	-1830.9**
	[-6.35]	[-3.01]	[-4.06]	[-1.74]	[-2.20]	[-2.75]	[-0.98]	[-4.55]	[-2.73]	[-2.88]
Turning Circle	185	156.7	-359.7	1430.6	282.5	468.2	37.17	-541.5	988.9*	824.2
	[0.56]	[0.49]	[-0.91]	[1.88]	[0.85]	[1.65]	[0.09]	[-0.96]	[2.31]	[1.91]
Brake	154.2	35	20.95	30.11	-64.98	-124.2	-155.5	19.08	-13.17	-4.204
	[1.19]	[0.33]	[0.17]	[0.30]	[-0.82]	[-1.19]	[-1.15]	[0.10]	[-0.08]	[-0.02]
Comfort	1165	1427.5*	-154.9	-121.9	1007.9	-28.7	-442.6	-686.8	1159.7	-214.2
	[1.28]	[2.17]	[-0.16]	[-0.10]	[1.25]	[-0.03]	[-0.48]	[-0.45]	[0.76]	[-0.12]
Reliability	171.1	-165.9	-246.9	967.7	230	918.5	2481.1**	-1430.4	-105.5	750.3
	[0.36]	[-0.23]	[-0.42]	[0.91]	[0.31]	[1.21]	[2.88]	[-1.88]	[-0.19]	[1.23]
City_gpm	-1800.1	373.2	-233.7	601.5	-497.8	-787.1	607.6	-969.4	-4098.6	-294.3
	[-1.99]	[0.45]	[-0.31]	[0.46]	[-0.70]	[-1.51]	[0.87]	[-0.73]	[-1.38]	[-0.31]
Highway_gpm	2032.6	-470.9	-891.2	1969	843.1	598.7	-809.6	1703.7	1631.5	3157.2
	[1.03]	[-0.26]	[-0.36]	[0.55]	[0.44]	[0.24]	[-0.38]	[0.53]	[0.91]	[1.35]
AWD	4523.2*	6510.4*	1399	5647	6858.1**	7155.3**	5125.4*	2707.2	7083.7**	
	[2.56]	[2.33]	[0.64]	[2.04]	[3.42]	[3.00]	[2.23]	[1.32]	[2.94]	
RWD	-1500.3	339.8	-37.8	-2589.1	-1145.8	-879.5	1883.9	-232.1	5472.5	
	[-0.60]	[0.15]	[-0.01]	[-0.65]	[-0.51]	[-0.31]	[1.10]	[-0.05]	[1.72]	
WD4	11903.0**	11038.1**	7418.3	-10023.9	162.8	973.4	9328.5*	-2048.5	5850.2*	
	[3.49]	[3.41]	[1.93]	[-1.98]	[0.06]	[0.35]	[2.58]	[-0.71]	[2.11]	
FCT	783.3	-1131.7	1991	1102	-1784.8	2032.6	460.4	-2877.3	-663.1	-805.3
	[0.93]	[-1.12]	[1.60]	[0.37]	[-0.97]	[0.82]	[0.23]	[-1.65]	[-0.63]	[-0.76]
SCT	5192.8**	1024.4	-2379.7	7121.2*	-872.4	-2425.8	7012.8	1780.1	-4004.3*	-1232.2
	[3.21]	[1.07]	[-0.50]	[2.51]	[-0.54]	[-0.95]	[1.41]	[1.06]	[-2.76]	[-1.38]
_cons	-36130.4	-5785.8	31410.5	-95487.0**	20347.4	5535.7	-24327.8	60950.1*	10585	-6015.5
	[-1.45]	[-0.32]	[1.01]	[-2.77]	[1.00]	[0.16]	[-0.50]	[2.30]	[0.35]	[-0.15]
N	65	72	75	46	60	43	37	59	39	36
R-Squared	0.8284	0.8044	0.7939	0.813	0.8401	0.7527	0.7466	0.7163	0.7712	0.7334

t statistics in brackets * p<0.05, ** p<0.01, *** p<0.001

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